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1.	Mastering the digital marketplace: includes related articles on digital value chains Grocery Headquarters, September 1, 1999, Pg. 33(5), 3614 words, Aldrich, Douglas F.

2.	FSbuy.com Partners With Vitria to Dramatically Enhance Its E-business Solution for the Foodservice Industry Business Wire, May 22, 2000, Monday, 958 words

3.	Total cost of ownership: elements and implementation. International Journal of Purchasing and Materials Management, September 22, 1993, Pg. p3(9), 6211 words, Ellram, Lisa

4.	Utilizing inventory flow models with suppliers Journal of Business Logistics, 1996, Vol. 17, No. 1 Pg. 35-61; ISSN: 0735-3766; CODEN: INCCDU, 5022 words, Farris, M Theodore II

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Grocery Headquarters

September 1, 1999

Mastering the digital marketplace; includes related articles on digital value chains

BYLINE: Aldrich, Douglas F.

SECTION: Pg. 33(5) Vol. 65 No. 9 ISSN: 1094-1088

LENGTH: 3614 words

The digital economy is a weird, wild place. Much of what you have learned and practiced successfully will no longer be relevant. In an excerpt from his new book, Douglas F. Aldrich of A.T. Kearney makes the case for a new way of thinking.

It's said that a seasoned farmer can sniff the air and predict approaching rain. That she can predict crop yield by tasting the soil. That there are people who have a special intuitive talent for figuringout exactly where you should drill your well. You may have even personally had a "gut feel" about something and taken action - even though you had no logical basis to do so.

We see this happening. We see experienced CEOs becoming wary. Savvy business executives in a broad range of industries tell us they canfeel - that they know - big changes are coming. This is not based ondata, fact or logical forecasts. Change of the type we're talking about defies forecasts, because forecasts are based on traditional experiences and expectations. Visionary CEOs sense this, and are looking for help making the leap to paradigms that haven't yet been imagined,much less created.

For those of you who do recognize what lies ahead, you may have tomake radical adjustments in the current way you do business. For others, you will need to stop what you are doing - immediately - and begin anew.

A successful strategy is not about trying to maintain the status quo, even if that were possible. ("If we want everything to remain as it is, it will be necessary for everything to change," wrote Italian author Giuseppe Tomasi Di Lampedusa.) A successful strategy is not about creating barriers to entry for would-be competitors. It's not about cutting costs to maintain a marginal price advantage. A successfulstrategy is about coming up with new ideas, about thinking creatively, about innovative actions that take nothing for granted.

As we enter the digital economy, we need to leave behind our 20th century logic and management tools and begin developing ones that will work in the 21st century. Where nothing is sacred, nothing is given, and technology will continue to evolve beyond anything we can imagine today.

A new business model: The digital value network

Don't be scared by the jargon. A digital value network (DVN) is really just a community of business partners and customers that is connected using information technology. But simply integrating your traditional supply chain by using information technology doesn't a DVN make. The players in a digital value

network work together to maximize their combined value propositions for the benefit of the end consumers.

And - perhaps most importantly - a digital value network is a muchmore dynamic entity than a traditional supply chain. The relationships within a DVN are fluid - forming, disintegrating and reforming based on market dynamics and the whims of the consumer. Yesterday's supplier might be today's customer and tomorrow's competitor. Adam Brandenburger coined the term co-opetition to describe the win/win nature of these new business relationships in which elements of both cooperation and competition drive all players to produce ever increased valuefor their customers, consumers and shareholders. The one-for-all-and-all-for-one philosophy of the DVN is that the network will support the diverse business goals and decisions of all members (and, of course, all interested investors).

Digital value networks are enabled by the tight electronic linkages found in digital value chains - highly efficient business relationships that allow for synchronous executing of business processes across the extended enterprise. These electronic links are often made possible through the use of a standards-based technology platform that allows partners to executive a traditional business function in a digitally enhanced way. We call this a digital function platform (DFP).

There's also a new form of business intermediary that supports digital value networks - an infomediary. These new intermediaries provide a number of information-based functions that support the operation of the digital value network.

The appeal of the DVN model is that it will produce superior market valuations for companies that embrace it. Investors are understandably excited - but hard work is still ahead before the theoretical promise can be turned into a sustainable operational reality.

Components of a DVN

Since the advent of mass market retailing, manufacturers and vendors have made the most of their customers' buying decisions. Companieschoose what consumer needs they will meet, what markets they will serve, what product and service configurations they will offer, and what prices to charge.

Being a consumer in the industrial era has thus generally meant accepting limited choices and accepting compromise, often settling for the best available option even if it isn't a perfect match.

One of the primary drivers of the digital economy is the rise of the empowered consumer. Consumer intelligence grows exponentially as more individuals interact as members of a community made possible through digital communications. We call it the "law of increasing knowledge," similar to the "law of increasing returns." As more consumers interact within a growing community, they attain more knowledge about the value-added aspect of products and services in the marketplace. Empowered by this knowledge, digital consumers have started making muchmore intelligent decisions about the products and services they buy.

We believe that consumers will increasingly demand additional simplicity, quality, customization, improved content and, especially, time savings from market offerings. The DVN relies on this consumer-centric approach to business.

Producers of products initially form a digital value chain to create a far more efficient, rapid and flexible version of the traditional supply chain (remember pipeline velocity?). The digital value chainby necessity involves participants from a spectrum of separate businesses. One or more of these participants may take on the role of an "anchor," much as a major retail establishment usually serves as the anchor in a shopping mall. The anchor in a digital value chain is the power player around which the digital value chain is organized and often optimized. For example, whereas a Nordstrom might be the anchor in a local shopping mall, Dell Computer is the anchor in a digital value chain for producing personal computers, workstations and servers.

A particular business might assume the role of an "anchor" based on a number of factors. It may be providing the major share of the value delivered to the consumer (as most people go to the mall for the major department stores, not the ancillary businesses), it may be the dominant supplier (Procter & Gamble controls the vast majority of thevalue chains through which its products flow), or it may be the owner of a product or a

service that cannot be duplicated by any other participant in the value chain (Wal-Mart owns the physical retail outlet and the brand recognition that draws the consumer to its stores). In some cases, the benevolent anchor works to maximize value to all the participants within the digital value chain, but more often the anchor is focused on maximizing its own profits.

Dell is a classic example of an anchor; its particular digital value chain also includes component suppliers such as hard drive manufacturers, monitor manufacturers and the like, as well as R&D technologysuppliers and after-sales support suppliers. As the anchor, Dell calls the shots, establishes the rules, decides on technologies, and, inthis instance, owns the consumer relationship.

Value chains and supply chains are relatively familiar concepts. It's the digital aspect of digital value chains that is providing exciting new ways to create value and minimize costs. Just look at the transformation of the traditional supply chain of the automotive industry into a digital value chain. Traditional auto dealers incur big infrastructure costs to operate their businesses - leasing prime locations; maintaining large, expensive inventories; paying employee salaries and commissions, etc. - costs that were automatically assumed to bea permanently fixed overhead for doing business. Digital pioneers (like autobytel.com, CarPoint, etc.) use the Internet to create a digital value chain that not only reduces the costs associated with the traditional supply chain - no physical lots, no physical inventories, for starters - but have also made buying a new car a more pleasant experience for the consumer.

Digital function platform

Cross two digital value chains, and what do you get? A digital function platform (DFP). A digital function platform is simply a business service or technology platform that supports business processes across multiple value chains. Through a digital function platform, previously disconnected and autonomous value chains (e.g., the tire value chain and the headlight value chain) are able to collaborate and combine their offerings (e.g., create a car) more efficiently.

Digital function platforms can include a software package such as SAP or a turnkey business service such as Federal Express Powership. The common denominator in any DFP is that it is primarily digital in nature (and we don't mean using a fax machine); it can be applied across multiple value chains; and that it provides a new way for those value chains to efficiently cooperate and create value for the consumer.

The concept of a digital function platform is something of an artificial construct - a made-up thing. We've chosen to name it in order to highlight the dramatic way these new digitized platforms are greasing the wheels of the digital economy, and subsequently enabling the creation of digital value networks.

Things as basic as Microsoft Word, or the set of ANSI EDI standards, can be considered digital function platforms. When you need to exchange documents with another company efficiently - even a company in another value chain that you've never dealt with before - Microsoft Word provides a platform. In the not-so-distant past, such an exchangewas infinitely complicated by myriad possible file formats, disk formats, applications and transmission alternatives.

Likewise, the standardization of communications protocols across the Internet enabled by ANSI EDI standards has resulted in immeasurable efficiency benefits for a broad number of people participating in innumerable value chains. At this level, the entire Internet can be considered the grand-unified digital function platform for the digital economy.

Although a digital function platform can be as simple as a shared file format, it can also be a much more sophisticated set of productsand services. Increasingly we are seeing the creation of turnkey business services that are able to unite value chains in order to serve a variety of consumer industries.

The strength of a digital function platform lies in its cross-network integration, which allows it to take advantage of cross-country opportunities. By employing horizontal business networks, a digital function platform reduces cost and increases value for all stakeholders.

The new middleman - the infomediary

The word infomediary has been used to describe a wide range of companies and services in the digital economy. John Hagel and Marc Singer used the term in their book, "Net Worth," to describe companies that collect and manage access to consumer information. Many firms are now emerging to provide these intermediary services between consumers and the companies that want access to their information - primarily over the Internet.

Others used the term infomediary more broadly - to describe a whole host of services around the collection and dissemination of all sorts of information (not just consumer information). We use the term here in a broader sense: to describe a variety of information-based intermediary services.

An infomediary service can involve the collection, dissemination and control of a variety of types of information. It can also be any person or organization that facilitates the exchange of information between other parties - such as a company that matches buyers and sellers in an electronic market.

Much has been made of the recent trend toward disintermediation oftraditional middlemen. As distribution channels have become flattened and companies have recognized the need to reach their customer directly rather than through third-party sales channels, many types of traditional middlemen have been struggling. But in the digital marketplace, there is a whole new set of services that must be provided to facilitate trade - services that previously were not possible or necessary.

What do we mean by this? Simply that buyers and sellers still needto find each other, exchange information and arrange for payment anddelivery of goods and services. Some products and services still need to be aggregated or combined before they create a compelling offering for the consumer. The consumer still needs to become educated on products and services in ways that producers may not be able to provide. Someone still needs to establish a price that the consumer is willing to pay while maximizing profits. So if traditional middlemen are on the outs and the retail channel is being threatened by the Internet, who is going to provide these necessary functions? Why ... the newinfomediaries of course.

Let's look at some of the specific types of roles that infomediaries perform to enable the operation of a digital value network.

* Integrating services and needs. The infomediary takes existing products and services and combines them to create a new offering that has a visibly higher value. For example, Add-a-Photo takes the electronic photo uploading capabilities provided by PhotoNet and integratesthem with American Greetings' electronic cards to create a service that allows users to personalize on-line greeting cards with the photos of their choice.

* Aggregating services and needs. By gathering suppliers and buyers to a single virtual space, the infomediary leverages volume transactions. Freight forwarders are a good example of companies that take shipments of goods from many sources and bundle them to make the shipments more economical.

* Creating a "floating" pricing system based on supply and demand.Buyers and sellers can therefore shop for, trade, auction off or otherwise exchange products and payment in a dynamic online environment that reflects up-to-the-minute market conditions. Online auction houses like eBay are classic examples in this category, eBay facilitates an online auction so that individual buyers can bid on products from a broad range of sellers - products that span more than a thousand categories.

Some infomediaries may elect to organize the demand side (or buyers of a product or service) within a DVN; others may elect to organizethe supply side, or sellers in the network. For example, Amazon.com and Computer ESP have chosen to focus on the needs of the buyers; while companies such as Fast-Parts, NetMarket and CUC International concentrate on helping the sellers in their market niches. Still another model brings together several specialized infomediaries under one umbrella. For example, the online service AOL is in a sense a super-infomediary, providing subscribers with a portal to a great many specialized infomediaries.

A digital value network, therefore, combines these elements - digital value chains, a digital function platform, related infomediaries and, of course, the consumer - into an integrated whole. Together, these

participants in the network act in ways that benefit all members of the network in ways that previously would not have been possible.

It's important also to understand that any of the digital components used to create a given DVN might also be used to create other DVNs. For example, Amazon.com's digital function platform was built to help purchasers locate and select books; but it turned out that the online bookseller's chief value had nothing to do with books per se. If tomorrow there were no books to be sold, Amazon could take the same business model, apply it to some other kind of product and still be successful, because the service it provides is based on information. A whole new DVN could be created in, say, wine retailing, quite easily.

To date, only a few companies have moved from possessing a traditional supply chain to becoming part of a digital value chain, onto theultimate step of forming a digital value network.

There is ample evidence to suggest that early forms of DVNs are emerging, most based upon early EDI private networks, but some rallyingaround Internet-based infomediaries such as AOL and eBay. We believe, from some of these early attempts, that DVN pioneers can expect superior investment returns virtually every step of the way. However, these early experiences also suggest that commercial success does not necessarily start with copycat maneuvers.

Moreover, premature attempts to launch a DVN could, in fact, be a recipe for disaster - especially if the basic infrastructure requirements for success are not yet in place. Companies must begin by thoroughly understanding the building blocks essential to success in basic electronic commerce. Each step taken should improve the firm's ability to deliver value to its customers; each step must also pass a hard-headed test to make sure it helps the overall business (there are many things that your customers would love, but which would send you to bankruptcy court).

A successful DVN therefore must be carefully crafted by adopting an evolutionary strategy. Gain experience in the market, assemble allies, build relationships and enhance your electronic business capabilities in stages. An evolutionary strategy, however, does not mean going slowly. It, in fact, requires a great deal of speed. A successful DVN requires bringing together many participating entities, each with its own mature set of capabilities, and doing so as quickly as possible.

Beginning the DVN journey

A digital value network (DVN) isn't created overnight, and you can't put the business on hold while you fill the whiteboards with your "master plan." Moving from business as usual to a digital value network can and must be done in a way that supports and enhances your current business model while moving you incrementally in the right direction.

The first step to move properly into electronic commerce is to design a customized entry strategy based on your particular industry. For example:

* Manufacturers should begin by setting up a digital value chain that in the short term will help reduce costs and improve efficiencies. In the long term, of course, you should continue adding capabilities that enhance the value you offer to your partner companies in the value chain. This is a starting point, from which the goal should be to grow into a true digital value network.

One major chemical company is in the process of doing this by implementing a system in which storage capacity levels are rapidly communicated via satellite to headquarters. This sets up a replenishment schedule, and then electronically sends the information to a trucking company, which ties the information into a routing schedule letting the trucks know where to go and when. The company's ultimate goal is toextend from this starting point into a DVN capable of interacting with customers, suppliers and technical experts around the globe.

* Traditional wholesalers, distributors and retailers need to begin by staving off the risk of disintermediation (being eliminated). Specifically, they can protect their positions in existing supply chains and value chains by setting up a digital function platform (DFP) that leverages the business' value-adding

capabilities and anchors the business in multiple value chains. For example, automotive dealerships could leverage their position as parts distributors by offering more products and services to repair shops, end consumers and after-market automotive performance stores that complement their existing product and service portfolio.

After successfully building this initial DFP, an ambitious organization could grow into a true digital value network with links to manufacturers and designers, providing an enhanced ability to develop customized products.

By initially setting up the digital function platform that conforms most closely to today's business environment, companies increase the likelihood of success and position themselves for future growth.

* Current intermediaries must concentrate on initiating infomediary services associated with their current offerings, customers and brands. The goal is to exploit the value of existing activities by extending them to this new digital realm. Care must be taken, however, to ensure that the necessary digital function platforms are in place. For example, EDS and InterWorld are developing an infomediary service for the Hong Kong Harbor that will facilitate data sharing among all shippers, exporters and manufacturers who use the harbor - a potentialmarket of 230,000 companies. As the system evolves, these companies will become electronically (and strategically) linked to other essential services, such as ground support.

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Business Wire

May 22, 2000, Monday

FSbuy.com Partners With Vitria to Dramatically Enhance Its E-business Solution for the Foodservice Industry

LENGTH: 958 words

DATELINE: SUNNYVALE/ANAHEIM, Calif., May 22, 2000

BODY: FSbuy.com Joins Vitria Business Network and Adopts Vitria BusinessWare(R) to Build eCommunity Linking its eAuction and eRFP Applications to Foodservice Professionals

FSbuy.com has selected Vitria Technology Inc. (Nasdaq:VITR), the leading e-business platform provider, to electronically link its proprietary applications and business processes to customers and partners via secure Internet connections.

Under the terms of the agreement, FSbuy.com joins the Vitria Business Network (VBN), a network of tightly connected businesses that can be built upon as the network expands.

"Our selection of the Vitria e-business solution enables our members to rapidly link with any and all trading partners throughout the global community regardless of their respective systems," said Tim Carda, co-founder and chief executive officer of FSbuy.com.

"Joining the VBN exponentially expands the number of trading partners and service providers we can link to. As a result of this initiative, we will significantly accelerate our efforts to bring new products and services to the marketplace."

Vitria's e-business platform provides the means to link FSbuy.com to its members' internal inventory control, purchasing, shipping and accounting systems, providing FSBuy.com eCommunity members with access to detailed information about their supply chain management process.

Participation in the VBN will also enable FSBuy.com to bond electronically with its key partners and suppliers, enabling automatic, real-time exchange of information and transactions. These electronic bonds will leverage a variety of business-to-business e-commerce standards, including XML and EDI.

By automating the flow of information and transactions across the entire value chain, FSbuy.com will support its members' efforts to reduce the time and costs associated with managing the foodservice procurement process online. The VBN will also provide FSbuy.com with access to a large and growing network of other trading partners, services and products to complement its own.

The VBN is a network of Vitria-enabled trading communities that facilitates quick and easy electronic access to a wide range of product and service providers in a variety of industries.

By joining the VBN, FSbuy.com can use Vitria's BusinessWare(R) e-business platform to electronically bond to its own trading partners as well as other pre-existing communities, thereby accelerating its ability to bring new products and services to market and streamlining its delivery chains.

By providing this functionality out-of-the-box, Vitria enables FSbuy.com to accelerate time to market and

reduce the time required to link to new trading partners.

"FSbuy.com is showing how the eCommunity concept can change the rules in a traditional industry that we are all familiar with," said JoMei Chang, president and CEO of Vitria. "The combination of FSbuy.com's domain expertise, BusinessWare(R) and the VBN bring a leading proposition to the foodservice industry, and we look forward to working with Tim and his team as they address this outstanding opportunity."

About FSbuy.com

FSbuy.com is a "buyer-centric and vendor-neutral" e-commerce solution for the foodservice industry. The site unites foodservice buyers with distributors, dealers, reps and manufacturers through a single, industry-specific Web site offering the "complete package" from food/paper, beverage products, equipment, smallwares/tabletop, janitorial and office supplies to consultants and service providers.

This is a single-point-of-entry system for pre-qualified buyers and vendors to access industry information and current news events, as well as a one-stop shopping tool for daily procurement, bidding, auctioning/reselling, budgeting and real-time reporting.

About Vitria

Vitria Technology is a leading e-business platform provider. Vitria's e-business platform, BusinessWare, automates mission-critical business processes across the extended enterprise, reducing time to market, shortening lead times, lowering operating costs and increasing customer satisfaction. Vitria is a publicly traded company (Nasdaq:VITR) based in Sunnyvale.

For more information, call 408/212-2700, visit the company's Web site at www.vitria.com or send e-mail to info@vitria.com.

This news release includes forward-looking statements that are subject to risks, uncertainties and other factors that could cause actual results to differ materially from those referred to in the forward-looking statements. Such factors include, but are not limited to, risk as related to market acceptance of Vitria's product, deployment delays or errors associated with these products, hardware platform incompatibilities, reliance on a limited number of customers for a majority of revenue, need to maintain and enhance certain business relationships with system integrators and other parties, ability to manage growth, activities by Vitria and others regarding protection of proprietary information, release of competitive products and other actions by competitors, year 2000 problems and economic downturns in either domestic or foreign markets. These forward-looking statements are generally identified by words such as "expect," "anticipate," "intend," "believe," "hope," "assume," "estimate" and other similar words and expressions.

Note to editors: BusinessWare(R) is a trademark of Vitria Technology Inc. All other names may be trademarks of the companies with which they are associated.

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FOCUS - 3 of 7 DOCUMENTS

International Journal of Purchasing and Materials Management

September 22, 1993

Total cost of ownership: elements and implementation.

BYLINE: Ellram, Lisa

SECTION: Pg. p3(9) Vol. V29 No. N4 ISSN: 1055-6001

LENGTH: 6211 words

INTRODUCTION

For years, purchasing departments in many companies have talked about purchasing based on "total cost" rather than just price. Unfortunately, few companies have the information or the reporting systems readily available to them to support such a goal. "Total cost of ownership" (TCO) is a phrase used to describe "all costs associated with the acquisition, use, and maintenance" of a good or service.|1~

Like the total cost concept in logistics, the total cost of ownership examines the cost associated with purchased goods and services throughout the entire supply chain. Thus, TCO considers costs all the wayfrom idea inception, as in working with a supplier to develop a new or improved part, through warranty claims associated with that part once the final product is in use by the customer.

This article provides background information about key TCO concepts.It defines TCO and, based on case studies of nine firms that use TCOapproaches, it discusses the benefits of using the TCO approach. To facilitate the understanding of TCO concepts, a framework is developed that divides purchasing related costs into pretransaction, transaction, and posttransaction elements. In addition, the article describestwo general approaches for implementing the TCO concept, discussing both the benefits and disadvantages of each approach.

TOTAL COST OF OWNERSHIP IS DIFFERENT FROM MOST APPROACHES

TCO differs in two important ways from most models that attempt to look at the "cost" of doing business with a supplier. First, TCO considers a broader spectrum of acquisition costs than do most cost of ownership systems. Second, TCO attempts to look at life cycle costs, which consider costs associated with using a given item from a given supplier during the entire life of the item, including costs incurred once the item is in use.

For example, for capital equipment, postpurchase costs involve everything form maintenance, repairs, downtime, and obsolescence through to the ultimate disposal of the asset. For a component or material, total cost includes failure costs of the item once in use, such as warranty claim costs, lost goodwill, replacement, and similar costs. TCO issues associated with both of these types of purchases are expanded in the following sections.

TCO BENEFITS

TCO is a relatively complex method for developing an understanding of the true cost of a purchase. Yet, the firms studied in this research all believe that the benefits of TCO outweigh the major barrier to TCO implementation and execution--namely, the lack of readily available data to support TCO operation.

Major TCO benefits cited by the firms studied are shown in Table I. For convenience in discussing these benefits, they are grouped into five categories: benefits associated with (1) performance measurement,(2) decision making, (3) communication, (4) insight/understanding, and (5) the support of continuous improvement efforts. Although a benefit may fit into more than one category, for ease of discussion each benefit is considered in light of its most important role.

The "performance measurement" category of benefits includes those that improve the quantitative measurement of supplier performance. It includes such issues as the following: TCO is a good way to evaluate suppliers; TCO provides a quantitative method for measuring the results of supplier performance improvement/quality improvement efforts; and TCO provides an excellent tool for benchmarking. In benchmarking, TCO data can be used to compare suppliers, or to track changes in a supplier's cost performance over time.

TCO also supports improved decision making. TCO forces the quantification of tradeoffs in terms of dollars. It also provides a good basisfor supplier selection decisions, because it provides complete cost data on the important cost issues. Thus, TCO creates more informed decision making, in a structured, systematic way.

TCO can also help improve both internal and external communications for the purchasing function. The system provides solid data to communicate to suppliers regarding their performance. It also represents animportant way to get others within the firm involved in purchasing decisions--by providing data, or identifying relevant cost considerations.

The depth of the TCO approach also provides important insights and deeper understanding into the true nature of supplier performance. Theinformation developed using TCO regarding a supplier's total costs can be used to track the supplier's costs over time, or to compare with other suppliers. Such detailed information provides excellent data for negotiations, and can help focus target pricing efforts. TCO alsohelps purchasing personnel develop an awareness of the significant nonprice factors that affect their firm in the case of certain buys. This insight can help in negotiations, and in determining which nonprice cost elements a supplier should provide, and which can be foregoneor obtained more economically elsewhere. Finally, TCO provides a better understanding of purchase decisions by taking a long-term, big picture approach. It looks beyond price to explore how purchasing activity affects the firm's total costs both today and in the future.

All of these categories of benefits represent proactive means for purchasing to help continuously improve some aspect of the firm's or the supplier's operations. The last major benefit category includes those benefits specifically aimed at supporting a firm's continuous improvement efforts. By identifying various critical cost elements and their values, TCO helps focus a supplier's efforts on improving the "right thing." TCO also uncovers cost savings opportunities by highlighting large cost elements. Internally, TCO allows firms to gain an understanding of how their requirements (delivery, inventory, unique specifications, and so on) may actually increase costs of ownership. It may be prudent to modify such requirements. Finally, TCO represents a method for the

purchasing function to support the firm's overall continuous improvement efforts by broadening the perspective of purchasing personnel, and improving purchasing's decision-making process.|2~

CURRENT TCO PRACTICES

Recent studies indicate that the total cost of ownership concept is not widely understood or utilized in the purchasing function today. A1991 survey of National Association of Purchasing Management (NAPM) members indicated that 85 percent of the respondents were familiar with the TCO approach. Further, 69 percent said they would be comfortable either using or interpreting the results from a TCO model.|3~

To provide further insight, a group of purchasing managers attendinga cost savings workshop at NAPM's 1991 Annual International Conference was studied to determine the degree of utilization of the TCO concept. Because of the group's interest in purchasing cost savings and analysis, it was assumed that those responding to this survey would bemore progressive in the costing approaches than would the average purchasing manager.

One hundred three managers participated in the study, the results ofwhich are shown in Table II. Ironically, only 18 percent use a formalized TCO approach for evaluating purchases. Fifty-eight percent indicated that they use a TCO approach on an informal basis, and 24 percent indicated that they make no attempt to use TCO in analyzing purchases.

Table II

NAPM COST SAVINGS WORKSHOP SURVEY: RESPONDENTS WHOSE COMPANIES USE TCO IN EVALUATING PURCHASES

Response	Percentage Responding
Unsure	0
Yes, Formal Model	18%
Yes, Informal Model	58%
No	24%
Total	100%

N=103

An informal TCO approach represents a method in which cost factors beyond price, such as the cost of rejected materials, are informally considered in supplier selection and evaluation. For example, a buyer might be aware that one supplier produces frequent invoicing discrepancies. The time and effort spent correcting these problems increases the cost of doing business with that supplier. While unaware of how much such error correction costs the firm, the buyer makes a mental note of it. Thus, while such factors have an impact on the firm's perception of the supplier, those factors are not specifically "added in" and accounted for as a cost of buying a particular item or service from a particular supplier.

On the other hand, a formal TCO approach explicitly recognizes cost factors in

addition to price as part of the cost of doing business with a particular supplier. The number of cost factors considered, the manner in which the data are gathered, the types of cost factors, andthe precision of the costs vary greatly from firm to firm. At a minimum, any TCO approach should include transportation costs, receiving costs, quality costs (inspection, rework, reject costs), purchasing administrative expenses, including management time, and of course, theprice of the purchased item.4 In practice, some firms do leave out one or more of these costs, often the administrative costs.

A review of the TCO literature indicates that costs such as quality and delivery are the most commonly included items in total cost of ownership models. Service costs frequently are included as well. Service costs vary widely in nature, but typically include costs associatedwith issues such as whether the firm has a compatible EDI system, the cost of delays while working with the supplier to rectify a problem, and similar items.|5~

The "traditional" supplier selection model that is closest to the TCO approach is the cost ratio approach. In general, the cost ratio approach considers the costs the firm incurs internally that are associated with quality, delivery, and service.|6~ Thus, like most models firms use under the name of total cost analysis, cost ratio models are more limited in the scope of costs considered than a true TCO approach. The breadth of costs considered by TCO is discussed further in thefollowing sections.

COST ONCE A PRODUCT IS IN USE

Many firms that use a TCO approach are excellent at accounting for costs that occur prior to and during the purchase of a good or service. These firms usually have a good grasp of how much time, effort, andexpense is involved in adding suppliers to their systems and in placing orders. They know the value to their firm of on-time delivery, how much it costs to follow up on problems, match receiving with invoices, and even cut checks. However, once the item or service is consumed, these firms often lose track of the costs associated with the purchase. Thus, the area in which most TCO models in use today fall shortof the spirit of a true TCO model is in the analysis of costs associated with an item once it is in use. As mentioned earlier, there are a number of costs that should be considered once a product is in service. Because these costs are often significant, and vary greatly by type of buy, they are discussed separately in the following paragraphs.

Component Parts and Materials

Once a component or a material is consumed in the manufacturing process and becomes part of the end product or service, the purchasing function traditionally has become detached from further analysis. Costsassociated with the failure of a component or material once in possession of the customer are rarely tracked and communicated to the purchasing function. Yet such costs, which are frequently incurred after the product or service has left the company, should be very relevant to the supplier selection, evaluation, and retention process. Indeed,an understanding of such costs is critical in providing the best value not only to the producing firm but also to the customer, the ultimate judge of the firm's value.

Experience has shown that it costs a great deal to develop a customer. A recent study indicates that improving customer retention by 2 percent produces the same profit impact as reducing costs by 10 percent.|7~ Thus, the loss of a customer or customer goodwill because of faulty inputs can be costly to the firm as a whole. Taking an integrated, systems approach to purchasing, the impact of purchasing's supplierselection and management decision can be very

relevant to the customer service provided by the firm as a whole.

Capital Goods

In most cases, the price of a capital item is only a small part of the total cost of the item over its lifetime use.

Production equipment is a good example. A model used by one of the firms studied indicates that the price of a piece of production equipment for the firm's operations is around 35 percent of the total cost of that piece of equipment over its life cycle. For this firm, and many other manufacturing firms, costs incurred after the asset is in use account for 50 percent or more of the TCO. These costs are often termed "life cycle" costs, because they are incurred throughout the life of a piece of equipment, as that equipment is used.|8~ Critical costs that need to be considered in the total cost of ownership for production equipment include costs such as yield loss of production materials, maintenance costs, downtime, repair and overhead costs, and idle time costs for staff. Thus, there are many longer term cost factorsbeyond the initial price of the equipment.

Operating capital includes items such as personal computers, cars, copy machines, and similar items. Some of the costs associated with operating capital once in use include maintenance, replacement serviceswhen equipment is down, lost staff time, and lost goodwill. There isa great deal of overlap between the nature of costs included in the "costs once in use" portion of TCO for production capital and operating capital items.

Maintenance, Repair, and Operating Supply Items (MRO)

Some of the largest costs many firms associate with MRO items are cost of failure and associated replacement costs when in use. However, MRO items tend to be the "80 percent of the items" that make up "only20 percent of the dollar value of purchases." Thus, because MRO items are very transaction intensive relative to their price, in some cases a true total cost perspective may reveal that the lowest TCO comesfrom maintaining inventory. Consequently, a TCO approach must weigh the costs of maintaining inventory, and potential obsolescence risks,with the potential downtime and other inconvenience costs associatedwith not stocking an MRO item.

Some firms delegate to a third party distributor the management of their MRO items. In such cases, the buyer usually pays the third partymore "out of pocket" than if the items were purchased directly from individual MRO suppliers. However, such a system may cost less in terms of the total cost of ownership by utilizing the distributor's expertise, volume buying leverage, and improved emergency responsiveness,and by reducing internal costs through paperwork reduction, error reduction, and lower inventories.

Services

It is usually more difficult to pinpoint costs incurred after a service has been performed because of the intangible nature of the service. Some of the issues are also intangible; for example, does the service performed meet the user's needs and leave the user feeling "satisfied"? More tangible issues that should be part of the TCO for services include items such as the user's need to have follow-up or rework done because of incomplete or unsatisfactory service performance, costs of service agreements, and costs of services performed outside of service agreements.

A FRAMEWORK FOR UNDERSTANDING TOTAL COST OF OWNERSHIP

In an earlier study, the researchers suggest a model for understanding the total cost of ownership that groups purchasing activities intosix categories:

(1) quality, (2) management, (3) delivery, (4) service, (5) communications, and (6) price|9~ Another logical way to view the costs of ownership is based on the order in which the cost elements are incurred, that is as they relate to the transaction sequence: pretransaction, transaction, and posttransaction. These latter categories, which are based on a customer service model developed by LaLonde and Zinzer, have been adapted to fit the TCO concept.|10~

Pretransaction Costs

As indicated in Figure 1, pretransaction costs are those costs that occur prior to receiving the purchased items, and even prior to placing the order. Pretransaction costs include all costs incurred from the time that anyone within the firm begins to think about and investigate the possibility of buying an item, up to, but not including, order placement.

Some of the costs that may be overlooked are the costs of investigating alternative sources, qualifying and educating suppliers regardingthe firm's systems and expectations, and adapting to the systems, styles, and delivery methods of new sources of supply. As one of the firms studied pointed out, "Buyers will do anything to reduce price. They tend to forget how costly it is to add a new supplier to our system, increase the number of checks cut, prequalify the supplier, and soon." Because these costs are often not accounted for based on the transaction that created the costs, such costs are frequently overlooked. Thus, supplier selection and the addition of new suppliers is considered to be "free," when that clearly is not the case.

Transaction Costs

Transaction cost elements are those items that are related to order placement and receipt, and include the price of the item or service itself, as shown in Figure 1. Included are those costs associated withactually placing an order and getting the order in to the firm or supply chain, ready for the next value-added process. As such, transaction costs are those costs associated with preparing and placing the order (EDI, Fax, phone, and so on), following up on the order, receiving, matching receiving data to the invoice, and paying the bill.

Transaction cost elements tend to be more widely recognized than pretransaction and posttransaction costs, because these are the costs that occur in closest time, space, and relationship with the transaction itself. Costs that are sometimes overlooked in compiling transaction costs are purchase order preparation, auditing and matching of order, receiving and invoice payment, and correction of incorrect documents.

Posttransaction Costs

Posttransaction costs are those costs that occur after the purchaseditem is owned by the firm, in the possession of the firm, its agentsor customers. The actual occurrence of posttransaction costs may be soon after the order is received, or years later when the purchased item is in use or being modified, repaired, or disposed of. The more distant in time a cost occurs from the transaction, the less likely itis that the cost will be recognized as explicitly related to the purchase of a certain item from a certain supplier. As previously discussed, costs in this category are the most frequently overlooked by firms. Posttransaction costs frequently overlooked include product repair in the field, routine and special maintenance costs, costs associated with replacement part scarcity and/or obsolescence, and similar issues. These costs are often difficult to track, and may be separated form the purchase by a great deal of time.

For component parts, a firm is more likely to associate posttransaction costs with a particular buy if they occur soon after the transaction. Such costs may

include line fallout, part failure in finished goods testing, and field failure that occurs soon after the sale. For capital equipment, posttransaction costs such as equipment downtime, repair, and maintenance typically are recognized as being associated with a particular piece of equipment. However, rarely does a firm thatdoes not use a TCO approach account for those costs separately and go back and review the capital acquisition decision from a TCO perspective.

Development of a Process Flow Chart

Before beginning the implementation of a TCO approach, it is critical for a firm to have an understanding of its major costs of ownership. To help identify these costs, the firm can use the transaction costframework just discussed to identify the total costs of ownership for each purchase category (components/materials, MRO, capital for production, capital for support, and services) management is interested in exploring. While individual items within each category may vary slightly with respect to relevant cost elements, the development of sucha flow chart can provide a great deal of insight into the potential issues affecting each category.

A proposed format for such a process flow chart is shown in Figure 2. It includes several examples of the types of costs that could fit into each major category. While purchasing can begin constructing the chart based on its knowledge of the transaction flow, it is advisableto get input from other functions that are directly affected by incoming purchases. This may include input from accounting, engineering, quality, and other functional areas.

TOTAL COST OF OWNERSHIP IMPLEMENTATION

The preceding discussion of the potential elements that make up the total cost ownership for a given purchase from a given supplier is byno means comprehensive in nature. The myriad of issues and costs that may impact the TCO for an item is almost endless. Given that most firms do not have detailed cost data readily available, nor do they have systems for monitoring and tracking TCO, a simplified approach to total cost of ownership analysis is essential to make TCO workable, without becoming overwhelming.|11~ Detailed suggestions for refining the data gathering process to support TCO can be found in the author'searlier study.|12~

There are several approaches a firm can take in implementing a TCO philosophy. First and foremost, the organization must move away from solely a price orientation, to grasp the idea that "total cost" may bemuch more important than price. To experienced TCO users, this may seem like an easy task. However, for a firm that has been operating ina highly price competitive market, focusing on supplier price reduction, TCO may be a very difficult concept to sell to others within thefirm. Indeed, one of the firms studied found that in using the TCO approach, it had to avoid use of the term "cost." Cost immediately drove the firm's buyers to look at price, which is often the largest TCOcost element. Instead, they chose to use the term "value."

Implementation Issues

The development and implementation of a TCO approach in purchasing will likely be a major undertaking for a firm for a variety of reasons. The first critical issue, as mentioned above, is that the firm mustmove away from a price orientation to a TCO philosophy. Purchasing may have to demonstrate that a TCO philosophy is a superior way to manage and understand costs. The proof may have to come through a successful TCO pilot operation.

Second, few firms have accurate cost information for the pretransaction, transaction, and posttransaction cost components. Even fewer firms have this detail data at an item level. Thus significant effort may have to be devoted

to:

1. Develop a process flow chart, as discussed, to sharpen the focus on the firm's pretransaction, transaction, and posttransaction cost elements.

2. Determine which cost components are significant enough to warranttracking. Use Pareto's Law coupled with common sense. There are probably a few key cost components that make up the majority of TCO expenses for a given item.

3. Determine how those significant cost components will be tracked.

4. Gather and summarize the relevant cost component data.

5. Analyze the results.

For most firms, data gathering will begin as a significant manual effort.

Third, the firm needs to determine where to begin its TCO efforts. Should it begin with one item, a family of items, items that fit into different buying categories--such as a component, a capital equipmentitem, and so on? This decision is very individual by firm, dependingon the industry and the firm's overall and TCO philosophies. This third issue is discussed more fully in the next section.

Fourth, a firm must begin to think about how and where TCO will be used. Will it be a tool reserved for critical items, or will it be more broadly used? Will TCO be used to select suppliers, manage costs with current suppliers, or allocate purchases among suppliers? Will oneTCO model be used to provide the data to support all those efforts? The proposed scope will have an impact on the way n which a TCO approach is implemented.

There are two basic TCO implementation approaches. The first, a TCO pilot study, is based on the selection of one or a handful of items to begin with. A TCO approach for the firm is then developed, based onactual experience with the pilot items. The second approach involvesa "full" implementation, where the TCO model is basically implemented simultaneously for all items that will use the TCO philosophy. Bothapproaches are discussed below.

Pilot Study

A pilot study is based on the premise that a wise approach to use inimplementing an untried concept is to focus on a small, easily controlled group of items. Eight of the nine firms studied followed this approach. TCO may begin with one item--it may be a component, regularly purchased capital item, regularly purchased service, MRO item, or something similar. It would be ideal to pick an item that meets the characteristics in Table III; however, this may not be possible. If there is no item available that meets all the characteristics in Table III, one should be chosen with as many of those characteristics as possible.

The characteristics in Table III are suggested because an item that meets those characteristics has a high probability of creating a successful first project. Such an item may illustrate that the TCO is indeed much higher that the price. Because an item with some individually large transactions costs that the firm can affect is chosen, purchasing and/or other functional areas may be in a position to reduce costs significantly based on the TCO analysis data. In addition, in gathering information about TCO, others in the firm must be involved. If other functional personnel develop an interest, there will be more support for gathering and analyzing the TCO information. Others in the firm may have insight into bottleneck or problem areas associated with an item that purchasing is unaware of.

The benefits of beginning with a pilot study are summarized in TableIV. The

pilot study can be a valuable learning experience to help ensure that the subsequent expansion of TCO flows more smoothly. Further, a pilot may be the only alternative if the TCO approach does not have full top management support.

Full Implementation

Some firms have decided to skip the pilot TCO implementation and itsassociated learning, and forge right into implementing their "vision" of a TCO model. Firms may choose to do this when they have full topmanagement support or when they believe the need for a TCO approach is urgent. In addition, they may feel very comfortable and confident that they understand the TCO approach and how they would like to develop it within the firm.

Among the firms studied, only one took this approach. Some members of the purchasing function had been using an "informal" TCO approach prior to implementing the formalized approach. This firm implemented TCO without a pilot when a new chief financial officer was appointed. This individual was convinced that TCO was a superior supplier management tool. The benefits of full TCO implementation are shown in TableV.

The firm did have some problems with implementation--data were not readily available, there were delays in reporting, and so on. But withtop management support, these pitfalls were overcome. A year later, although the TCO model is still evolving to some extent, this firm has an excellent model in place. The model is used throughout the firm for guiding the buying and management of key purchased components andmaterials for manufacturing.

CONCLUSIONS

TCO represents an important means for the purchasing function to addvalue to the firm. It is more than a tool. TCO is a philosophy that guides purchasing in the supplier selection decision as well as in supplier evaluation, negotiations, and volume allocation among suppliers.

Relatively few firms in the United States have implemented a formal TCO approach. Yet the number is growing, as firms continue to recognize that price is not the all-important supplier selection criterion. Firms interested in implementing a TCO approach must first develop anunderstanding of the specific costs that are important in their firm. One way to do this is to develop a process flow chart that tracks apurchased item through the entire supply chain--from pretransaction (order placement), to transaction (order receipt), to posttransaction(subsequent use and disposition). This activity in itself can provide some very useful, insightful information. A process flow chart, such as the one shown in Figure 2, can help identify the major cost elements in addition to price, and provide focus and direction in developing and implementing a TCO approach.

This step, however, is only the beginning. Many decisions associatedwith the TCO implementation process must be made--from deciding whether to have a pilot study to deciding which items should be included in the formalized TCO approach. While TCO requires a major implementation effort, it clearly produces major benefits for the firm. As pointed out by the firms studied, TCO supports better supplier performance measurement, improved decision making in supplier selection and related areas, better internal and external communications for the purchasing function, greater insight and understanding of cost issues related to purchasing, as well as a firm's continuous improvement efforts.

Future research should continue to explore TCO implementation issues. Further, since one of the primary issues that creates difficulty inTCO implementation is the lack of TCO data, it would be beneficial to direct some research effort toward the development of improved datagathering ap-

proaches.

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Table I

BENEFITS OF TOTAL COST OF OWNERSHIP

Performance Measurement

Good framework to evaluate suppliers Concrete way to measure resultsof quality improvement efforts Excellent tool for benchmarking

Decision Making

Forces purchasing to quantify tradeoffs Good basis for making supplier selection decisions More informed decision making Creates a structured problem-solving environment

Communication

Excellent communication vehicle between a firm and its suppliers A way to get other functions involved in purchasing decisions

Insight/Understanding

Provides excellent data for trend analysis on costs Provides excellent data for comparing supplier performance Provides excellent data for negotiations Provides critical data for target pricing Requires purchasing to develop an awareness of most significant

nonprice factors that contribute to TCO Provides a long-term orientation by focusing on the "big picture"

Support Continuous Improvement

Helps identify where suppliers should focus improvement efforts--drives suppliers to work on the "right thing"

Helps identify cost savings opportunities

Forces a firm to look at internal issues--how their own requirements/specifications may actually increase costs

Encourages professional growth in purchasing personnel by broadeningtheir perspective

Figure 1 MAJOR CATEGORIES FOR THE COMPONENTS OF TOTAL COST OF OWNERSHIP

TOTAL COST OF OWNERSHIP

Pretransaction Components

1. Identifying need 2. Investigating sources 3. Qualifying sources
4. Adding supplier to internal systems 5. Educating:

* supplier in firm's operations

* firm in supplier's operations

Transaction Components

1. Price 2. Order placement/preparation 3. Delivery/transportation
4. Tariffs/duties 5. Billing/payment 6. Inspection 7. Reurn of parts
8. Follow-up and correction

Posttransaction Components

1. Line fallout 2. Defective finished goods rejected before sale 3. Field failures 4. Repair/replacement in field 5. Customer goodwill/reputation of firm 6. Cost of repair parts 7. Cost of maintenance and repairs

Table III

CHARACTERISTICS OF AN ITEM FOR PILOT TCO PROJECT

* The firm spends a relatively large amount of money on that item.

* The firm purchases the item with some degree of regularity, in order to provide some historical data, but more important, to allow opportunities to gather current cost data.

* Purchasing believes the item has significant transaction costs associated with it that are not currently recognized.

* Purchasing believes that one or more of the currently unrecognized transaction costs is individually significant.

* Purchasing has the opportunity to have an impact on transactionscosts, via negotiation, changing suppliers, or improving internal operations.

* Those purchasing or using the item will cooperate in data gathering to learn more about the item's cost structure.

Table IV

BENEFITS OF TCO PILOT STUDY

* Gain understanding of data sources/unavailability

* Experiment with alternative TCO models (e.g., standard vs. flexible cost components in all models)

* Educate others in the firm regarding TCO

* Improve cooperation within the firm by getting others to participate

* Convince people in the firm of the benefits of TCO by demonstration

* Become familiar with the TCO model and possible pitfalls

Table V

BENEFITS OF FULL TCO IMPLEMENTATION

* Widespread results throughout the firm

* Fast benefits

* Fast development of TCO understanding

* TCO gets attention--requires focused commitment

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Utilizing inventory flow models with suppliers

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Efforts to reduce cycle time through the channel have historically been secondary to schedule optimization and cost reduction. Cycle time reduction offers as much impact on inventory levels as schedule or cost changes. Measuring the impact of change in cycle time relative to optimum inventory levels is difficult, especially when cycle changes involve multiple functional organizations or companies. Flow modeling, a technique that simplifies the analysis of the relationships between cycle changes and inventory levels throughout the supply chain, is introduced.

A common challenge facing logistics managers is the problem of reducing inventory without adversely affecting such other components of the logistics strategy as cost effectiveness, product availability, process and materials flows, and timely delivery. Two common approaches for managing inventory levels are schedule optimization and cost changes. During the past decade the management of cycle time has increased as a means of inventory management. A useful technique for managing inventory levels through cycle time analysis is "flow modeling." The purposes of this article are to introduce flow modeling, describe the steps in the flow modeling process, and explain how flow modeling can be useful to inventory reduction programs.

The article is divided into five sections. The first section discusses the historical development of flow modeling from the early 1960s to the present. The second section describes the five steps of flow modeling. The third section focuses on key components of flow modeling. Next, specific applications of flow modeling are identified and discussed. Finally, implications of flow modeling for practitioners, teachers, and researchers are examined.

WHAT IS A FLOW MODEL?

Flow modeling is a tool to assist the management of cycle time at all levels of the organization and across all members in the supply chain. Flow modeling identifies both the time and cost associated with a process. Multiplied by a scheduling vector, the flow model will emulate the entire process. The flow modeling technique offers valuable insights to many of the strategic and operational decisions critical to successful operation in a competitive environment. The flow model utilizes components from common business decisions and may be used in both service industries and goods manufacturing.

Historical Development

Early conceptualization of flow modeling has been traced back to Hughes Aircraft's "inventory flow models" in the 1960s. Raytheon's refined use was detailed in a Harvard University "Leisure Products, Inc." case study in 1972. In 1977, Production Magazine cited Sirianni's modeling work at Westinghouse.1 Sirianni suggested using flow models as a method to calculate inventory requirements. In 1978, Gregory2 cited the

lack of methods to calculate work-in-process inventory levels, particularly in long cycle environments. He also proposed the use of flow to balance inventory investment against other demand. Developmental papers by Colley3 and Davis4 furthered the concept by increasing the level of detail within the flow model by breaking each activity into geometric segments. Colley and Davis suggested using the flow models as a means of goal-setting and performance measures. Flow modeling by companies such as Bendix and IBM is cited in the 1975, 1978, and 1983 American Production and Inventory Control Society (APICS) Conference Proceedings.5 Wantuck6 points out the flow model shape is germane to a given business configuration and concludes that no one flow model fits all situations. In addition, Wantuck suggests the flow model can be used to do more than calculate optimal inventory requirements, it can be used to identify overage inventory. Clark7 proposes a macro perspective by linking flow models to corporate balance sheets and income statements. Hughes8 further adds to flow model capabilities by tracing multiple flow models on a single chart representing different types of inventory in the product cycle. He recognizes the difference between "operational" inventory and "optimum" inventory and suggests extending flow models beyond the immediate plant. The use of flow modeling continues to be an effective technique to understand and analyze any process. The contribution of this paper is to identify how inventory flow models may be used and extended throughout the supply chain.

Step I: Gathering the Right Information

Primary components of a flow model include:

Cumulative lead time analysis of the time segments that make up a process.

. Cumulative value analysis of the build-up of value over time.

Schedule stated in terms of the daily going rate (DGR).

. Build structure reflecting relationships of components.

Collecting accurate and valid information requires interaction with manufacturing, production, design engineering, scheduling and planning, inventory and production control, purchasing, finance, and the accounting organizations in the company. The initial collection of information is the most critical aspect of the flow modeling technique. It requires a repeated effort to define and fine-tune the information. After the correct sources have been determined, the gathering of information becomes routine.

Step II: Begin with Cumulative Lead time Analysis

Analysis of cycle time often utilizes a sketch of the cumulative lead time. Cumulative lead time is the identification of all the elements that make up the total lead time of a part or assembly. It may take a variety of forms originating with a simplified diagram representing quoted lead times. Mather likens a cumulative lead time analysis to a pipeline flowing materials and products from vendors through the plant and off to customers.9 Further maturation of cumulative lead time diagrams will offer increasingly more detail for each major component or subassembly.

Lead time analysis diagrams can be quite extensive and extend across the entire supply chain from the purchase of raw materials all the way to the final end consumer. A typical manufacturing firm holds 30 percent of its inventory investment in procurement inventory, 30 percent in operational inventory, and 40 percent in distribution inventory.10It is important to do a complete analysis of the entire supply chain to capture all inventory reduction opportunities. Lambert suggests "while interdepartmental integration is important and beneficial, it's only a first step. Clearly the biggest payoffs from all this will come through integrating the entire supply chain."I Development of a cumulative lead time diagram is a critical first step in cycle time analysis. It allows the user to understand the time frames of each activity within a process.

Step III: Reflect Dollar Build-Up

Mature cumulative lead time diagrams aid the understanding of the production process, but they are limited in quantitative value as they only reflect cycle days and not the value of the inventory. Measuring

only changes in time may imprecisely report cycle improvement.

Consider a scenario in Figure 3 where two workers reduce cycle times in their respective processes. Assume each process originally takes 50 days. Worker A removes 20 cycle days from the raw materials end of the pipeline. Worker B removes 10 cycle days from the finished goods end of the pipeline.

It would be inappropriate to assume Worker A has achieved twice the benefit of Worker B just based on cycle days. It is intuitive that finished goods will maintain higher value than raw materials. Assume for this example that finished goods are valued three times higher than raw materials. Ten days removed from the finished goods portion of the process removes as much inventory from the process as 30 days removed from the raw materials end. Many cycle time reduction efforts focus solely upon the number of days removed from the cycle without regard for the value added during the cycle period. This assumption limits cycle reduction gains by misdirecting reduction efforts and causing suboptimal results. It becomes imperative to consider the multi-dimensional attributes of each segment within the process.

A second dimension provides more precise quantification of cycle day value by representing the cumulative investment of value for each stage in the cycle. A multi-dimensional representation may be differentiated from the traditional pipeline chart by designating it as a "flow model." In short, a flow model = cumulative lead time + cumulative investment valuation. At this point in the design, the model graphically creates a two dimensional pipeline where the shape represents inventory investment in a process. This relatively simple technique offers many opportunities to manage the overall business perspective.

Adjusting for Daily Going Rate (DGR)

Initial calculations for the flow model design are based on a daily going rate of one unit per day. To allow for easy computation for fluctuations in the rate of production, the flow model is comprised of a series of daily snapshots throughout the production cycle for manufacturing a single unit. Inventory levels reflect quantities held to support the manufacture of the single unit. A third dimension can be added to the model to adjust for a daily going rate larger than one by multiplying the variables along the Y-axis by the daily going rate. After adjusting for the daily going rate, the flow model takes a three dimensional shape (Figure 6). Most flow models are viewed on a two dimensional basis with supporting numbers reflecting the daily going rate.

Step IV: The Review Process

Peters states that "all of us must start 'thinking in wholes' and across boundaries, not about 'my' job, 'my' function, or even 'my' company. We must, in fact, reorient all of our structures and procedures, and our attitudes from parts to wholes; vertical to horizontal; exclusion to inclusion; transactions to relationships; functional task expertise to multi-function project execution; borders to 'spider webs' (networks)."12 The flow modeling technique supports this philosophy. In order to achieve a reduction in total cycle time, a company must shift its operational focus from individual functional silos to how operations interact and flow together. A manager must identify the real business process and ask fundamental questions about the way every piece of information and material flows.13

(Chart Omitted)

Captioned as: FIGURE 1

(Chart Omitted)

Captioned as: FIGURE 2

(Chart Omitted)

Captioned as: FIGURE 3

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Captioned as: FIGURE 4

(Chart Omitted)

Captioned as: FIGURE 5

(Chart Omitted)

Captioned as: FIGURE 6

A review should be conducted with all organizational players to ensure correctness and encourage communication. When initially viewed by all participants, there are often conflicting opinions on what the true process should look like. This is not unusual and may be the result of functional silos. It signals suboptimization of the process and opportunity for improvement. Over time, definition of the process will evolve. Joint review provides valuable interaction between functional areas and helps define a commonly agreed process for all organizations.

Check Proportions

Pipeline diagrams often are not drawn to scale. Proper proportionality in the flow model diagram will further emphasize the relative importance of each segment in the process. Notice the difference in the twenty days required to accumulate parts at the vendor in Figure 7 when the graph is drawn to scale compared to the unproportional pipeline diagram from Figure 5. The use of proper proportion helps to graphically identify the relative significance of each segment.

Step V: Add More Detail

Flow modeling is a dynamic evolutionary process that continuously seeks to fine-tune more details in targeted areas.

KEY COMPONENTS OF FLOW MODELING

Management by Eye Technique

Readability of the flow model may be enhanced through the use of shading common key activities. One successful practice defines each process using the following classifications:

(Chart Omitted)

Captioned as: FIGURE 7

1. Value Add (adding value to product in form of labor or the addition of parts).

2. Materials Movement (adding time/place utility to the product or components).

3. Strategic inventory (holding product at strategic locations in the process to accommodate the manufacturing process).

These classifications can quickly identify the responsibilities of functional areas. The example in Figure 8 classified activities by the functional organizations of manufacturing, distribution and transportation, and production and inventory control.

Flow modeling supports the "management by eye" technique by creating a single summary of the process flow in terms of time and financial measurement as well as identifying which functions manage each segment. The management by eye capability of flow modeling is helpful to identify processes with high variability. Van Amstel14 bases his pipeline analysis on the fact that "the longer and more complex the pipeline, the greater are the variations within lead times." Flow modeling reflects accumulations of strategic inventory to protect the process from the high variability. Reduction in variability will play an important role in

cycle reduction. Flow modeling may be utilized to seek out these pockets of high variability.

Both Detail and Overview Capability

Flow modeling may help to identify the process for a single part in manufacturing and logistics operations. Users of single part flow models include department managers, manufacturing engineers, or purchasing buyers.

The flow model may be extended by combining many parts into a higher level assembly or product. The complexity of the flow model will increase if all the information from each part level is utilized. It may be advisable to utilize averages in appropriate areas to allow for a simpler perspective of the higher level flow model. Users include product managers, purchasing buyers, and higher level management.

(Chart Omitted)

Captioned as: FIGURE 8

The flow model may be extended further to show the entire supply chain and identify logistical relationships between customers and suppliers. It may be utilized to identify strategic placement of inventory in the channel to maintain serviceability or reduce critical lead times. The seams (points where two processes come together) generally will offer the greatest opportunity for cycle improvements because each process will tend to increase cycle time to protect the uncertainty associated with the other process.

Multiple product flow models could conceivably be combined to reflect a business segment as long as the product schedules were dependent on one another. The flow modeling technique may be utilized to understand a process from many different levels, ranging from detailed through overview.

Determining Optimum Inventory

The flow model can quantify the optimum level of inventory required under the current cycle process. "Optimum inventory" is defined as the total amount of inventory that must be loaded into a process to support the manufacture of one unit per day. Total optimum inventory may be calculated by determining the area inside the flow model. Each unit area will measure one value unit times one time unit and will represent one value unit of optimum inventory required to support the process. The magnitude of financing required to support production or manufacture of a new product or business is often underestimated. The flow modeling technique provides a realistic estimate of inventory investment requirements.

The changes in the optimum inventory level required for a different production rate may be calculated by comparing values from each flow model after multiplying by the daily going rate.

Utilize as a Tracking Tool

Changes in inventory levels may be explained by investigating three basic variables: cost, schedule, and cycle times. Inventories will increase if there has been an increase in scheduled production, cost, or cycle times. Conversely, they will be reduced if the schedule is cut back, costs drop, or cycle times are shortened. The flow modeling technique may be utilized to summarize the impact of multiple changes to schedule, cost, or cycle times. It may be adjusted to accommodate varying production rates. In short, it may be utilized as an effective tracking tool reflecting changes to the process or business.

Developing a Compression Curve

The shape of a simple flow model reflects the build-up of product value over time. As flow models become more complex, all components must be combined, or compressed, together into a single line to summarize the build-up of value through the entire cycle. An example is shown in Figure 9 where the two operations from Figure 7 have been combined to create a single line.

Compression curves differ in curvature depending on the nature of the operation. Operations with high

materials content relative to the amount of labor added will have a convex shape. Those with high labor added content will have a concave shape. Compression curves provide visibility to the inventory and cash flow needs of the overall process.

Measure inventory at Risk

When a customer places an order commitment on a supplier, the customer has an obligation to receive and pay for the completed order, or in the event of a cancellation, compensate the supplier. This obligation represents risk by the customer. In the event of a cancellation, the customer should expect to compensate the supplier only for the amount of value added. Extreme situations of 0 percent cancellation charge or a 100 percent cancellation charge are financially unfair to one of the parties. Disputes arise when attempting to determine equitable financial responsibilities.

The flow modeling technique and compression curve shown in Figure 10 provides the visibility of the process to derive an unbiased assessment of the amount of value added at any point in the process. This measurement has been called "inventory at risk," which is the maximum risk a customer will incur in terms of inventory or cancellation charges in the event an order is canceled. For ongoing business relationships, use of the flow modeling technique and compression curves may be useful to help resolve disputes and ensure fair treatment of both parties. In the example, $ 1,800 would serve as a starting point for discussion of cancellation charges. Utilizing a flow model, both parties would have access to common quantitative information prior to discussion of cancellation charges. Other factors, such as scrap value or alternative use for the canceled order, would modify the cancellation charge from the initial starting point.

Engineering changes may cause cancellation (or postponement) of supplier orders and may result in significant addition to overhead costs. In 1985, prior to cycle reduction efforts, each Northern Telecom location (on average) made an engineering change to an existing product once every two hours. The cost of these changes accounted for more than 20 percent of manufacturing overhead.15 In a situation such as this, the ability to measure "Inventory At Risk" would be applicable to highlight the cost to cancel an order.

Postponement Analysis

The flow model may be utilized for postponement analysis when rescheduling delivery dates. Upon notification of postponement, it is assumed the supplier will remove the product from his process and hold it until it is time to reinsert it into the process to coincide with the new delivery date. (The alternative is for the supplier to complete manufacturing the product and hold the higher valued finished product for later delivery. Unless there are technical limitations preventing the interruption in the process, it is not advisable to continue to add value to the product as this will result in higher inventory carrying charges.) The compression curve is useful in determining the value of inventory and holding charges to be incurred. Holding charges should be calculated to cover the period of time the unfinished product will likely be held.

Quantifying Cycle Improvements

Flow models may be used to quantify the following benefits from cycle improvements:

(Table Omitted)

Captioned as: Example:

(Chart Omitted)

Captioned as: FIGURE 9

(Chart Omitted)

Captioned as: FIGURE 10

(Table Omitted)

Captioned as: Example:

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Captioned as: Example:

One time invenlory reduction.

Annual savings in carrying costs.

Unit price reduction.

Reduction in "inventory at Risk.

Calculating One-Time inventory Reduction

A change in cycle time will result in a one-time reduction in the level of inventory carrier to support the process. The savings will be in the form of excess inventory assets that may be reduced over time. Graphically, a reduction in cycle time shifts the compression curve toward the origin of the graph as shown in Figure II.

The one-time reduction in inventory can be quantitatively determined by subtracting the area under the revised compression curve in Figure 11 from the area under the original compression curve. The amount of the reduction represents the amount of capital that will become available for an alternative use.

Calculating Annual Savings in Carrying Costs

In addition to the one time reduction in inventory, there will be a reduction in the annual costs to carry the inventory that was previously tied up in the process. After excessive inventories are eliminated, the annual savings may be calculated by multiplying charges associated with carrying this inventory by the one time savings in inventory calculated above.

Calculating Unit Price Reduction

The costs of carrying inventory are included in the final unit price of the product. Reduction in inventory carrying charges may be reflected in a lower unit price. The annual inventory cost savings should be spread over all of the units produced annually. Unit price reductions may be shared between customer and supplier. The customer benefits from a lower unit price. The supplier benefits from increased profitability and a more competitive price.

Calculating Reduction in Inventory At Risk

When the compression curve moves toward the origin, inventory at risk is reduced. The change in the average inventory at risk can be a general benchmark to measure improvement. Average inventory at risk with the original curve is 50 percent of the unit price.

Summary

The benefits quantified from the example are shown in Table 1.

INDUSTRY UTILIZATION OF FLOW MODELING

Many companies have utilized the flow modeling technique for a variety of applications from:

(Chart Omitted)

Captioned as: FIGURE 11

(Table Omitted)

Captioned as: Example:

(Table Omitted)

Captioned as: Example:

(Table Omitted)

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(Chart Omitted)

Captioned as: FIGURE 12

(Table Omitted)

Captioned as: Example:

(Table Omitted)

Captioned as: TABLE 1

Reduction in inventory risk.

Improving supplier/customer relations.

Designing a new process.

Re-designing a current process.

Competitive analysis.

Supplier sourcing decisions.

Reduction in Inventory at Risk

A world-class manufacturing electronics company has been using flow modeling to analyze the degree of risk associated with channel relationships. The company has modified supply contracts to utilize flow models as a means of settling disputes concerning cancellation or scheduling changes. Contract terms require updating the flow models twice a year. All improvements are shared equally between the parties.

Improving the Supplier/Customer Partnership

A domestic manufacturer of printers has utilized flow modeling to improve the process flow with suppliers. The company is encouraging suppliers to implement flow models with their sources of supply.

After implementing a flow model to understand the process, bottlenecks, and associated risks, the printer manufacturer contractually agreed to accept full financial responsibility in the event of complete order cancellation (to a maximum of $ 40,000) for strategic raw material stores held by a key supplier. In return, the supplier agreed to hold additional strategic stock at his expense to accommodate unexpected schedule increases by the customer without extending lead times. Sharing strategic risks reduced cycle lead time by over 17 percent.

Designing a New Process

Concurrent engineering has had a dramatic effect increasing productivity and reducing costs for many

companies. Flow modeling was used when designing assembly and test operations to house the IBM 3990 Storage Control Unit. In-house cycle manufacturing time dropped from 45 days for its predecessor 3880 to two days. Space to house the operation required one quarter of that for the 3880.16 IBM initially constructed a flow model for the 3880 process build, then drew boundaries on the flow model to represent the cycle reduction goals. Purchasing lead times extending beyond twenty days were subject to challenge and potential re-sourcing. Any in-house manufacturing process extending beyond five days was re-engineered. The end result was an order-to-finish process contained within a twenty-day time span that provides quick response to the market.17

Re-Designing A Current Process

A major airbrake manufacturer used flow modeling to map the manufacturing process. The flow model identified queues in front of 27 test bottlenecks. Information from the flow model was utilized to justify the expense to rework the process and reduce it from 14 days down to four days.

Competitive Analysis

A producer of cathode ray terminals (CRTs) utilizes flow modeling to reverse engineer competitor products. The competitor's product is disassembled and estimates for manufacturing cycle time and cost are combined into the flow model. The competitor's flow model is printed on a plastic transparency and overlaid on top of the producer's own CRT manufacturing process for comparison.

Supplier Sourcing Decisions

An airframe manufacturer requires suppliers to include a flow model when they respond to a RFQ. Flow models incorporate many of the logistics activities into the total all-in cost analysis. IBM-Rochester, winner of the 1990 Plant Malcolm Baldrige National Quality Award, extensively utilized flow modeling for sourcing decisions for the AS/400.

SUMMARY

The flow modeling technique is a tool to help focus management direction. Used correctly, the technique can be beneficial to all members in the supply chain as summarized in Table 2.

Characteristics of a flow model include:

Can range from simple to complex details.

The result of multiple function inputs.

The result of many decisions.

Segments are typically managed well.

(Chart Omitted)

Captioned as: FIGURE 13

(Chart Omitted)

Captioned as: FIGURE 14

Opportunities are usually found in seams between processes.

Principle benefits of flow modeling include: . Ease of understanding lead time.

Identifies critical processes.

Usable as a negotiation tool to reduce "inventory at risk" and to ensure: fair treament of both parties.

Offers detailed perspective of a product.

Offers overall perspective of business including multiple members in the supply chain.

The flow modeling technique simplifies analysis of the relationship between inventory and changes in cycle. It incorporates cost, schedule, and cycle time; and may be an effective tool to understand and help strategically manage the supply chain.

(Table Omitted)

Captioned as: TABLE 2

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Healthcare Financial Management

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Integrating the Healthcare Supply Chain

BYLINE: Brennan, Charles D, MPPM, MEd

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HIGHLIGHT: By integrating healthcare supply chain processes, integrated delivery systems can achieve substantial cost savings and better focus their organizations on their core patient care mission

ABSTRACT:

Integrated delivery systems (IDSs) can eliminate unnecessary expenses and enhance the speed and quality of services they offer to healthcare providers if they redesign their supply chain. Redesigning of supply chain requires IDSs to integrate the different supply chain operations into a streamlined, cost-effective process that features considerable standardization, integration, and optimal service placement. For IDSs to succeed in integrating the operations of their supply chain, it is imperative that they meet, or exceed, if possible, "best practice" performance in the following areas: demand, orders, suppliers, logistics, and inventory. They should also remember that their supply chain integration should be based on the optimum configuration of the supply chain operations, without regard to the constraints of their implementation with the exception of fixed constraints such as geographic locations of their facilities. In addition, IDSs should make use of the following "enablers" that can facilitate their smooth shift to an integrated supply chain: information technology human resources change management and organization structure and good customer-supplier relationships. Article discusses how IDSs can develop a business model and outsourcing, and includes a table of best practices in healthcare supply chain management.

BY CHARLES D. BRENNAN, MPPM, MED

Today's integrated delivery systems (IDSs) require efficient supply chain processes to speed products to users at the lowest possible cost. Most excess costs within the supply chain are a result of inefficient and redundant processes involved in the transport and delivery of supplies from suppliers to healthcare providers. By integrating and assuming control of these supply chain processes, improving supply chain management practices, and organizing and implementing a disciplined redesign plan, IDSs can achieve substantial savings and better focus their organizations on their core patient care mission.

Many integrated delivery systems (IDSs) have reached the size, geographic coverage, and scale of operations at which the traditional model of decentralized support services creates inefficiencies and excess costs. To manage these services more efficiently, IDSs have sought ways to centralize management of core operational functions create production centers for food preparation, laundry, and other scale-sensitive services and implement standard policies and procedures systemwide.

Yet, to achieve and maintain the level of service efficiencies that will help ensure their long-term success,

IDSs increasingly will need to focus on integrating the entire supply chain. The supply chain is the chain of activities, information, and flow of funds that extends from manufacturers to the customer, or patient. Traditionally, marketing, distribution, planning, manufacturing, and purchasing have been independent processes within the supply chain, and the objectives of these processes have often conflicted. Effective supply chain management integrates these disparate processes to bring finished goods to customers faster and less expensively. Supply chain management has been compared to a well-practiced relay team. The team is more competitive when each player knows how to be positioned for the hand-off and gears his or her efforts to winning the race, not merely running the fastest leg.[a]

Proposing an Integrated Supply Chain Process

Currently, IDSs devote 20 to 30 percent of their operating budgets to supply chain costs, which include direct drug and supply costs and their associated labor, or process, costs.[b] In the past, process costs were difficult to measure and manage because they were distributed across different departments. As a result, IDSs tended to focus their cost management strategies on reducing supply costs, primarily through group purchasing, supply contract renegotiation, and product standardization.

Supply chain processes, however, have come under increased scrutiny as IDSs seek ways to simplify clinical and business processes within and across their organizations. Current healthcare supply chain processes incur avoidable costs in the following areas:

* Transportation from a production plant to a regional distribution center

* Distribution center operations

* Outbound freight

* Wholesale distributor's receiving and warehousing operations

* Wholesaler distributor's mark-up for information processing and customer service

* Transportation to the provider and

* Inventory.

An integrated supply chain would transform this disjointed string of activities into a streamlined, cost-effective process characterized by substantial standardization, integration, and optimal service placement. Traditionally duplicated functions, such as warehousing, transportation, purchasing, accounts payable, and information management, would be converted into integrated, standard processes with substantially reduced fixed costs and better operating efficiencies. By sharing common processes, all supply chain participants also would be able to share in savings. Reductions in the cost of transportation and distribution, for example, would be shared by both suppliers and providers, each of which traditionally invests in these processes individually and redundantly.

Improving Supply Chain Effectiveness

To successfully integrate the supply chain process, IDSs need to meet or exceed "best practice" performance in five supply management areas: demand, orders, suppliers, logistics, and inventory.[c] Exhibit 1 shows the savings potential of these best practices, expressed as percentages of total controllable operating expenses for an IDS. An IDS with budgeted, controllable expenses of $500 million annually, for example, could achieve savings of $12.5 to $30 million by comprehensively redesigning its supply chain.

Demand management. Managing consumption of clinical resources is key to controlling demand and ultimately reduces the number of supplies that move through the supply chain. Effective demand management is dependent on three practices.

First, demand should be forecast and a plan implemented to facilitate fulfillment of supply needs on a

quarterly, semiannual, or annual basis. While not easy to accomplish, this practice enables an IDS to better allocate inventory space and avoid excess staffing during periods of lower demand. It also results in more efficient production runs for suppliers and reduced capacity for distributors.

Second, as supplies are standardized and provided in a more managed flow, the opportunity to cluster and deliver them as a single unit of inventory to the point of use becomes possible. The advantages of procedure-based delivery are reductions in inventory, procedure preparation time, and waste.

Third, literature-based clinical guidelines should be developed to define supply requirements for key patient groupings. Such guidelines provide a foundation for anticipating supply demand and meeting it more efficiently.

Order management. Order management encompasses the process that begins with a request for a product or service by an end user and ends with provider payment for the product or service. Typically, IDS order management processes are highly fragmented and complex. Efficient order management depends on the following practices:

* Integration of purchasing and accounts payable processes to reduce fixed costs, centralize accountability, and establish standard order management processes.

* Implementation of a paperless ordering process through electronic data interchange (EDI) or other forms of electronic commerce and

* Implementation of an electronic product numbering and tracking process to simplify identification and tracking of orders and payments.

In particular, electronic numbering and tracking would facilitate inventory management across the system. Pending complete implementation of the universal product number (UPN) standard in the healthcare industry, healthcare systems may employ bar coding of the UPN (where available), manufacturer, product, and catalog numbers. This practice will provide a robust database in which the UPN is matched to a majority of the products used by the healthcare system.

Supplier management. Efficient supplier management begins with reducing the number of suppliers that provide products to the healthcare system. Compliance with group purchasing contracts helps reduce the number of suppliers and increases opportunities for discounts and rebates. Establishing relationships with fewer suppliers also enables IDSs to implement supplier-managed inventory arrangements, thereby dramatically reducing inventory carrying costs and stocking requirements. Moreover, using fewer suppliers enhances the potential for securing capital from key suppliers to support key supply chain investments.

Logistics management. Integrated, central logistics management is another key to efficient supply chain operations. As the focal point of all supply chain activity, the healthcare system can manage the logistics requirements for its supply chain and achieve substantial savings and process efficiencies.

Transportation is the major logistical concern. In most healthcare systems, transportation of supplies is characterized by multiple, independent trucking of material from manufacturer to distributor to each provider location. Shipments are not coordinated to ensure that trucks operate at full capacity and that routes are chosen to minimize transportation time and costs.

To improve efficiency, a consolidated service center and transportation network should be created to ensure efficient utilization of transportation services, manage supply chain logistical information centrally, and eliminate redundancy. Centralizing logistics management also facilitates collection and management of the data required to measure supply chain efficiency, evaluate service quality, and support effective demand management.

Inventory management. Inventory management savings can be achieved by reducing the number of storerooms systemwide, minimizing stocking levels, and maximizing inventory turnover rates. Key to successful inventory management, however, is standardizing all functionally equivalent products to a single

product.

Most IDSs are able to approach product standardization only superficially for two reasons: a UPN system has not yet been developed to help identify functionally equivalent products, and it is difficult to identify product characteristics that are equally meaningful to all physicians and staff members. Creating a product database for supply standardization can greatly simplify product evaluation and ensure that standardization opportunities for the full range of products used by the organization are identified.

Designing a New Supply Chain Process

The ideal supply chain design is the optimum configuration of supply chain functions, disregarding constraints on implementation other than certain fixed constraints, such as geographic location of facilities. In determining this configuration, all decisions about standardization, centralization, and process redesign should be based solely on the structure and economics of the underlying operating process. This analytical configuration should be the IDS's long-term goal and should be a yardstick for evaluating intermediate design compromises.

An important part of the design process involves balancing the ideal design with current initiatives, customer expectations, and organizational and technological capabilities. Retaining existing initiatives when they contribute to or complement the ideal implementation plan fosters organizational support of the redesign by acknowledging the innovative efforts of managers and staff.

An important limitation IDSs face in implementing service changes is user resistance. The design process should address this problem by educating customers about plan objectives so they recognize the benefits it offers, and by focusing initial supply chain redesign efforts where perceived customer needs and expectations agree with the plan's objectives.

Department directors are often skeptical about the effectiveness of systemwide redesign efforts. These customers should be included in the design process through focus groups, interviews, and participation on teams that develop recommendations. In addition, the IDS's administrative, corporate finance, information technology, and human resources staff should be involved in the design process from the beginning.

Many systems, although deeply committed to redesign, fail to anticipate the complexity, cost, and human impact of implementation. Investing sufficiently in the following "enablers" can help prepare an organization to transition to an integrated supply chain:

* Information technology systems and expertise, including technical infrastructure and application development capabilities, systemwide hardware/software linkages, commitment to or dependence on legacy systems, and preparation of information systems management and staff to assume a support role

* Human resources, including a communications strategy counseling, retraining, reassignment, and outplacement of staff and labor relations

* Change management, to help staff prepare for significant shifts in autonomy and control, customer service orientation, and skill requirements and

* Organizational structure and the relationship between customer and supplier, including changes in management structure, governance, accountability, incentives to meet the requirements of an integrated system, service levels, and performance feedback.

Developing a Business Model

Organizations often overlook the need for an accurate, comprehensive business model to analyze return on investment of major business process redesigns. IDSs should conduct a comprehensive financial assessment of a new supply chain process using four essential calculations: economic savings economic investment noneconomic factors and risk assessment.

Economic savings. The potential improvements in efficiency from the proposed initiative should be calculated. The financial assessment should explicitly identify the intended FTE reductions and specific product and service savings. The implementation schedule of all operational changes should be specified because timing will directly affect anticipated returns. If a new service model is proposed, it should be compared with the current model to identify exactly where and how economic efficiency would be improved.

Economic investment. The assessment should specify the capital and personnel investments required to redesign the supply chain. In addition, the investments in specific transition costs, such as recruiting, relocation, training, and communication, should be calculated.

Noneconomic factors. The assessment should evaluate the risks to successful implementation posed by management shortages, organizational culture, and operational complexity. It should describe the impact on staff morale and motivation. It also should quantify, where possible, the noneconomic benefits from improved service, such as reduced excess ordering among physicians and nurses.

Risk assessment. On the basis of the noneconomic risk factors described above, an appropriate discount rate for future cash flows should be calculated, using the IDS cost of capital as a base and taking into account the inherent risk of the proposed recommendations.

Outsourcing

Ideally, IDSs should strive to implement the supply chain process internally, but outsourcing is sometimes necessary. Before resorting to outsourcing, however, an IDS should thoroughly evaluate the best practices achievable internally. Understanding the intricacies and associated costs of internal implementation allows an organization to better estimate cost-service tradeoffs and issues that affect customer satisfaction, both of which are important in evaluating and pricing alternative suppliers.

Outsourcing is especially attractive for IDSs with aggressive growth strategies and a perennial shortage of resources for centralized activities. For instance, carefully structured outsourcing arrangements can create off-balance-sheet financing and make significant and rapidly changing technologies available with minimal investment in research and development on the part of the IDS.

The risks associated with outsourcing also need to be considered. By outsourcing for sophisticated technologies, for example, IDSs run the risk of being contractually tied to partners that may not be able to keep pace with rapid technological change. Other significant risks include loss of direct control of mission-critical functions, reduced opportunity for cross-training, and potential conflicts between the IDS's culture and an outsourcing vendor's culture.

Conclusion

By redesigning their supply chains, IDSs can achieve substantial savings while dramatically improving the speed and quality of the service they provide to their users. An integrated approach to supply chain management, implemented with care and discipline, can achieve these objectives and enable an IDS to focus more on delivering superior health care to patients.

Charles D. Brennan, MPPM, MEd, is a principal, APM Management Consultants, CSC Healthcare, New York, New York.

EXHIBIT I: BEST PRACTICES IN HEALTHCARE SUPPLY CHAIN MANAGEMENT

	Best Practices	Savings Potential
Demand Management	* Demand planning system * Demand-driven ordering, stocking, and packing tied to clinical	1-2.5%

	guidelines * End-user customization	
Order Management	* Consolidated purchasing * Paperless order management (EDI/electronic funds transfer (EFT/Internet procurement) * Complete UPN implementation	0.5-1.0%
Supplier Management	* Supplier consolidation * Optimal direct-from-manufacturer implementation * 90 percent compliance with group purchasing requirements	0-0.5%
Logistics Management * Integrated transportation	0.5-1.0%	
	network 85 percent use of transportation capacity * Consolidated service center	
Inventory Management * Standardization of	0.5-1.0%	
	supplies * Automated point-of-service distribution continuous replenishment * Nonstock items under 30 percent * 25 to 40 percent reduction in stockkeeping units	
Total Savings Potential	2.5-6.0%	

Study Documents Supply Chain Costs

In 1997, the Computer Sciences Corporation, New York, New York, under sponsorship of healthcare industry manufacturers, distributors, and providers, launched the Efficient Healthcare Consumer Response (EHCR) study to assess the efficiency and effectiveness of the overall healthcare industry supply chain. The study has documented national annual expenditures of more than $83 billion for supply chain processes, $23 billion of which represent process (eg, personnel, transportation, logistics, procurement, and payment) and handling costs. Analysis revealed that by working together, the healthcare community could cut supply chain costs by as much as $11 billion.

ECHR has examined every activity within the supply chain to determine whether its cost is warranted and is using the study results to develop and model for a responsive, consumer-driven supply chain in which manufacturers, distributors, and providers would collaborate to maximize clinical outcomes and patient satisfaction while minimizing costs.

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Outsourcing of integrated logistics functions An examination of industry practices

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A survey of 372 logistics managers in different industries revealed multiple outsourcing linkages among logistics activities. These results are consistent with previous findings that suggest that firms can improve customer service and reduce costs by outsourcing multiple logistics functions. The results are also consistent with previous research on the role that improved coordination of information and material flows have in the achievement of economies of scale and economies of scope. Future research developments in the field of logistics outsourcing are also proposed.

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Introduction

The outsourcing of logistics functions to partners, known as "third-party logistics providers", has increasingly become a powerful alternative to the traditional, vertically-integrated firm. A growth in the number of outsourcing partnerships has contributed to the development of more flexible organizations, based on core competencies and mutually beneficial longer-term relationships. A 1995 survey of the chemical industry by Van der Steen and Siegel (1995), for example, found that the average number of outsourcing partnerships per company grew from 1.5 in 1989 to 5.5 in 1994. Overall, some 60 per cent of Fortune 500 companies report having at least one contract with a third-party logistics provider (Lieb and Randall, 1996).

The development of logistics outsourcing - broadly defined in this paper as long and short-term contracts or alliances between manufacturing and service firms and third-party logistics providers - has been largely based on the needs that companies have to obtain cost savings and to concentrate on their core competencies. As indicated by Van Damme and Ploos Van Amstel (1996), the market and firm characteristics influence the decision to contract multiple combinations of third-party logistics services.

These services range from single transportation activities to integrated warehousing, distribution, and information management activities.

Also several authors have indicated that across many industries logistics outsourcing has become a rapidly expanding source of competitive advantage and logistics cost savings. For example, Lieb et al. (1993) reported that some firms routinely have achieved up to 30 per cent to 40 per cent reductions in logistics costs and have been able to greatly streamline global logistics processes as a consequence of outsourcing. Other studies, however, have indicated that some logistics outsourcing arrangements are not successful. These unsuccessful relationships have been generally attributed to unclear goals and unrealistic expectations, internal sabotage by managers at the firms engaging in outsourcing, and flaws in the contractual agreements linking the parties involved (Ackerman, 1996; Greco, 1997).

Authors such as Boyson et al. (1999) have indicated that the success of outsourcing agreements depends heavily on the management skills of the firms engaging the services of third-party logistics providers. These authors also suggested that the strategic outsourcing of integrated functions across the supply chain will be more effective than the gradual or piecemeal outsourcing of supply chain activities.

This paper builds on Boyson et al.'s analysis by focusing on how companies bundle the activities outsourced to third-party logistics providers in order to achieve the potential economies of scale and flexibility needed to compete in increasingly uncertain environments. We believe that such information is a valuable guideline to determine outsourcing synergies; that is to determine the combinations of logistics activities companies find that it makes most sense to outsource.

In particular, the study has the following primary objectives:

- To review the existing academic literature on logistics as a functional system and on integrated outsourcing of logistics activities.

- To offer an explanation as to why firms outsource particular clusters of functions and as to why the integrated outsourcing of logistics areas would be advantageous to those firms.

- To identify links in the way multiple logistics functional areas are outsourced and to measure the impact that the outsourcing of each functional area has on the likelihood of outsourcing other areas.

- To propose several future research areas in the field of integrated logistics outsourcing.

The remainder of this paper is structured as follows. First, we outline the theory on logistics functions that serves as a reference for the interpretation of the results. This is followed by a description of the research methodology adopted for this study. We then present the research results and draw conclusions and managerial implications from the current research. Finally, we present future research developments on integrative logistics outsourcing.

Theory base

In developing the theory base for our analysis, we will concentrate on previous research about interrelated activities in logistics systems and on previous findings on the processes involved in jointly outsourcing logistics activities[1].

Logistics as a functional system

In general, a functional system can be defined as a "collection of interrelated objects and the therefore interrelated activities in which these objects are engaged" (Granzin and Bahn, 1989). Research on modern functional logistics systems can be traced to the work conducted by De Hayes and Taylor (1974), who concluded that logistics systems were critical in providing the customers' time and place utilities associated with every final product. Bowersox (1974) complemented these concepts by noting that the conceptualization of logistics as a functional system is crucial to improving the efficiency in the flow of goods and information and to meeting low-cost, fast, and reliable delivery objectives within a firm and throughout a network of

firms. According to Bowersox, a system of logistics functions can be divided into five broad areas:

(1) facility location;

(2) transportation;

(3) inventory;

(4) communication; and

(5) material movement.

More recently, Novack et al. (1992) updated Bowersox's logistics framework by highlighting some of the misconceptions associated with a purely functional view of logistics activities. According to Novack et al. (1992), a linear functional sequence obscures major logistics objectives and complicates the management of logistics processes. Novack et al. (1992) recommended a classification framework in which the optimization of the logistics systems takes precedence over the optimization of individual logistics activities. Novack et al. (1992) introduced a new dimension to Bowersox's framework. As Figure 1, Part A shows, this new dimension divided all logistics activities into two categories. The first category includes the "physical activities that are required to create form, time, and quantity utilities of customer need" (Novack et al., 1992, p. 234). These activities encompass inventory, transportation, and customer service operations. The second category includes the "transaction activities that follow or initiate the physical activities previously presented" (Novack et al., 1992, p. 234). The activities in this category are centered on transaction negotiation areas (i.e. the interaction between firms through the purchasing of inbound materials, supplies, and products) and order cycle management areas (i.e. the management and control of information flows necessary to create customer service in the logistics system).

Authors such as Granzin and Bahn (1989) and Sharma et al. (1995) also refined Bowersox's work by applying the conceptual foundations of Bowersox's model to decisions and activities of consumers within a logistics framework (Figure 1, Part B). Granzin and Bahn's research contributed to the logistics research by identifying direct links between logistics operations and the final consumption of goods, i.e. through the provision of customer service, and by introducing a new customer-oriented logistical interface into the model.

Finally, authors such as LaLonde and Auker (1973), Langley et al. (1988), and Stock (1990), complemented previous research on functional logistics systems by highlighting the role of logistics information systems as operational and strategic enablers in multiple areas of the firm's supply chain. LaLonde and Auker (1973) detected that information technology was shifting from being an enabler of operational and material handling functions to being an enabler of decision-making and activity-planning functions within the supply chain's transportation and distribution area. Langley et al. (1988) established that computer technology had become increasingly linked to the planning, implementation, and control of traditional inventory activities such as product receipt, storage, order picking, and shipping. Stock (1990) found that many firms were able to reduce warehousing costs by routinely using information technology in their warehousing operations. These cost reductions were mainly attributed to the substitution of highly coordinated flows of information for assets (e.g. inventories, facilities and equipment).

Functional integration in logistics outsourcing

A majority of authors have concluded that, in general, effective outsourcing processes of individual or multiple logistics functions are driven by potential improvements in customer satisfaction - in terms of time, place, and form utilities - and cost effectiveness - as a result of a more effective use of financial resources in the development of core competencies (Fawcett and Fawcett, 1995). Researchers also agree that in integrating outsourced logistics functions across multiple functional areas firms can contract processes as opposed to discrete activities. The contracting of processes allows firms not only to streamline their flows of goods and information in their supply chains, but also to reduce costs associated with asset ownership, the monitoring of performance, and the hiring, management, and training of personnel (Maltz and Ellram, 1997). In essence, companies outsource clusters of non-core activities that create strategic subsystems.

Firms outsource the activities in these clusters because the activities have a joint impact on what customers perceive are important product attributes and because the activities in these clusters share highly specialized operational skills, physical assets, processes, technologies, and transactional information enabling the achievement of economies of scale (Venkatesan, 1992).

In translating these findings to the context of the logistics systems, we hypothesize that: firms will tend to outsource clusters of functions with the objective of achieving improvements in their logistics performance. For example, firms may jointly outsource logistics functions such as order processing, product returns, packaging, and shipment planning to better react to market demands and to maintain economies of scale arising from integrated customer delivery processes and consolidated customer orders (Alderson, 1957; Bucklin, 1965; Pine, 1993; Lee and Tang, 1997).

Furthermore, we expect that the coordination of flows of information and goods across the supply chain will play an important role in the logistics outsourcing strategies of firms. An efficiently coordinated flow of logistical information will make a firm more responsive to customer requests and will build greater customer loyalty and better customer-firm relations (Stock, 1990). Thus, our second hypothesis is that firms outsource groups of transactional functions across transportation, inventory and customer service areas.

We also believe that firms will outsource groups of physical logistics activities. A coordinated flow of goods will facilitate the integration of pricing, transportation, and inventory planning activities throughout the firm's supply chain (Lee et al., 1997). Often, however, the major difficulty in achieving such coordination lies on the capital asset commitments that firms must make. The outsourcing of clusters of activities leading to a coordinated flow of goods will allow firms not only to avoid extensive capital asset commitments, but also to achieve lower ordering costs for raw materials and parts, and lower inventory carrying and stock-out expenses.

Furthermore, the outsourcing coordination of flows of goods will allow for economies of scale and economies of scope that might not be feasible otherwise (Lee et al., 1997). For example, by consolidating loads from multiple suppliers or distribution centers located near each other, a third-party logistics provider can realize full truckload economies without having truckload components originating from the same supplier. Similarly, a third-party logistics company can utilize frequent (on a daily basis) truckloads to deliver to customers in common geographic areas. Thus, our third hypothesis is that firms partnering with third-party logistics providers will be interested in integrating their services across logistics areas that are linked by active flows of goods.

In addition, it is expected that the outsourcing of information systems will play a central role in regulating the flow of information to and from customers and in optimizing the internal flow of information across the transactional areas of the logistics system (Juga, 1996). As Greis and Kasarda (1997) indicated, logistics information systems have the power to create economies of conjunction, which are derived from the occurrence of multiple events and transactions (e.g. customer ordering, freight payments, and shipment planning) in a single time and place. For many firms, however, the direct costs of acquiring comprehensive and complex logistics information technology can almost never be economically justified from a short-term perspective. In many cases, firms choose to contract the operation of their logistics information systems with third-party logistics providers in order to realize the economic benefits associated with logistics information technology without extensively investing on capital assets and human resources (Drucker, 1993). Our fourth hypothesis is, therefore, that firms will integrate the outsourcing of logistics information systems with the information flows across transactional functions such as inventory management and shipment planning.

Finally, we anticipate that in order to achieve economies of scale, improve delivery performance, and expand geographic coverage, firms will outsource bundled transactional and physical functions within transportation, inventory, and customer-service areas (hypothesis 5). Indeed, functions in these areas share complementary routine operations such as the stocking of finished goods and the planning of inventory and shipping requirements. Furthermore, the functions have complementary capital assets such as warehouses and vehicles and share technological tools such as databases and data and material transmission channels.

A summary of the hypothesized relationships among outsourced logistics functions is presented in Table I and Figure 2. (While Figure 2 includes an example of the type of bundling that exists under Hypothesis 1, other types of bundling under this hypothesis are also possible.)

Research methodology

The present study is part of an ongoing research project addressing critical logistics outsourcing practices. The sample for this paper was drawn from the subscribers to the industry publication, Transportation and Distribution (T&D). A survey instrument was sent to the 11,571 subscribers in the USA (out of a total subscriber list of about 71,000) who indicated to T&D that they had logistics outsourcing experience and decision-making authority over outsourcing within their firms[2].

Two sections of the survey are relevant in addressing the research objectives presented above. As the Appendix illustrates, the first survey section questioned respondents about the extent of outsourcing and the patterns of logistics activities outsourced. We inquired as to the logistics functions that were currently performed, had previously been performed, and might be performed in the future by third-party logistics providers. We also asked the respondents to indicate the number of years during which the third-party logistics firm had performed each of the logistics functions for them. The second survey section asked respondents to identify their firms' annual sales, number of employees, and geographic scope of operations. Furthermore, this section included demographic information that allowed us to keep track of our respondents. The demographic information included the respondents' names, positions, contact information, and their firms' names and lines of business.

Before mailing the questionnaire, several members of the local Council of Logistics Management Roundtable were asked to pre-test the survey and to provide comments regarding the level of clarity and objectivity of the questions, the accuracy and applicability of the answer options, and the amount of time spent on the questionnaire. Suggestions were used to refine some of the questions and to add new answer options.

The survey was sent to all names on the T&D "outsourcing" list and a follow-up notice was sent one week after the initial mailing[3]. A total of 463 usable surveys were returned [4] and [5]. There were no two surveys returned from the same plant or warehouse location, although 22 surveys were returned from multiple locations of the same firm. Each location may represent a separate business unit or activity with an independent supply chain/logistics system. For the purposes of this study, we assumed that multiple locations in the same firm could be considered independent responses.

Two of the 463 respondents indicated that their firms were presently engaged in logistics outsourcing, however, they did not specify which functions were being outsourced. These two observations were removed from the sample. Furthermore, 89 respondents indicated that their firms were not presently engaged in outsourcing and were, therefore, removed from the sample, leaving 372 respondents.

The low response rate (4.32 per cent) based on the 463 respondents may have been owing to the very detailed nature of the questionnaire. Alternatively, the low response rate might have been caused by the sensitive nature of some of the information requested. Despite the low response rate, it should be noted that the total number of surveys returned represents a very large database for logistics research. A review of three leading logistics journals revealed that most published studies on logistics outsourcing have been based on results from no more than 250 responses[6]. The total number of responses included in our study provided a wide coverage of industry sectors and supported a variety of statistical tests.

In order to perform a thorough non-response-bias test, in the manner of Mentzer and Flint (1997), we contacted a random sample of 30 non-respondents and asked them to answer eight key non-demographic questions (i.e. questions that have to do with the theory base empirically analyzed in this paper) that were part of a total of 11 non-demographic questions in the original survey instrument. In two of the eight questions tested, non-respondents selected multiple choices, while in the other six questions non-respondents rated a total of 49 items. Chi-square tests of critical response distributions to the two multiple-choice questions showed no statistical differences (at the 0.05 significance level) between

respondents and non-respondents. Furthermore, independent t-tests of the responses to the other six questions showed no statistical differences (at the 0.05 level) between the ratings by respondents and non-respondents in 47 of the 49 items evaluated[7]. These tests, therefore, establish an absence of non-response bias in the survey's theory-base content.

In addition, our survey respondents provided information on their companies' SIC codes (i.e. Standard Industrial Classification). Approximately 70 per cent of our respondents represented companies in the manufacturing segment, with an additional 10 per cent in the wholesale trade group and 7 per cent represented firms in the retail trade group. For the most part, as the chi-square analysis in Table II illustrates, the SIC-code distribution in our sample of 463 logistics practitioners were not significantly different (at the 0.05 level) from the SIC-code distribution among the population of 11,571 managers.

Finally, respondents to our survey included logistics managers from 21 of the top Fortune 50 firms and from 35 of the top Fortune 100 firms. In total, our respondents represented 114 of the companies on the Fortune 500 list. We also found that a higher percentage of the survey respondents represented large firms (as measured by the number of employees) as compared to the population of firms[8]. As a caution, therefore, our results are more likely applicable to larger firms in the population (as represented by the T&D list).

Survey results: the integration of third-party logistics services

Survey findings revealed that many firms tend to outsource multiple logistics functions. As Table III shows, survey respondents currently engaged in relationships with third-party logistics providers are outsourcing an average of 2.5 logistics functions. Furthermore, almost 71 per cent of the respondents currently engaged in logistics outsourcing are partnering with third-party logistics providers in at least two different logistics areas.

In order to determine how the firms in our sample are bundling the services of third-party logistics providers and address the research objectives included in Section 1, we first grouped the outsourced logistics functions into six functional areas as per the typology established by Bowersox (1974); Novack et al. (1992); Granzin and Bahn (1989); Sharma et al. (1995). As illustrated in Figure 3, the six functional areas included: transportation/transactional, transportation/physical, inventory/transactional, inventory/physical, customer service/transactional, and customer service/physical. Complementarily, logistics information systems were kept as a separate linking instrument in accordance with the theory developed by LaLonde and Aucker (1973), Langley et al. (1988), and Stock (1990)[9].

Next, we developed a statistical analysis to test our hypotheses. Our main analysis centered on the estimation of Pearson's correlation values to identify pair-wise linkages between all areas in the logistical system. In addition, to complement these results, we used logistic regression equations to measure the probabilities associated with outsourcing combinations of activities across different levels of firm size. In the remaining part of this section, we summarize and interpret the most important results from the correlation analysis. In the interest of brevity, note 12 summarises the main results obtained from the logistic regression. The overall results from the logistics regression models are available from the authors on request.

Pair-wise linkages between all areas in the logistical system

Table IV presents the Pearson correlation coefficients for the outsourcing of all the logistical areas previously identified. Of the 21 correlation pairs used, 11 were significant at the 0.01 level and two additional correlation pairs were significant at the 0.05 level. The 13 statistically significant correlation pairs are included in Figure 4 and their interpretation is presented below[10].

Table IV and Figure 4 illustrate a significantly positive pair-wise association among outsourced logistics functions in inventory/transactional, inventory/ physical, customer service/transactional, and customer service/physical areas. The fact that there is a positive outsourcing association among these four logistics functional areas supports Boyson et al.'s findings regarding the outsourcing of clusters of functions to

achieve performance improvements in the firms' logistics activities (Hypothesis 1).

Table IV and Figure 4 also illustrate that there is a significantly positive association between outsourced logistics functions in the transportation/physical and inventory/transactional areas. This outsourcing relationship adds validity to our view that firms tend to jointly outsource logistics areas that share an active flow of goods and information (Hypotheses 3 and 2, respectively). Indeed, logistics functions in the transportation/physical and in the inventory/transactional areas involve a sequence of complementary transactions that will routinely begin with the forecasting of inventory and the planning of shipments and will end with the transportation of goods to and from the firms' warehouses. In addition, we found a significantly positive association between outsourced logistics functions in the inventory/physical and in the customer service/physical areas (Hypothesis 3). These two logistical areas share a steady flow of goods. They involve a sequence of operations that originates with the packaging of goods for storage and ends with the operations needed to consolidate and repackage the goods for delivery.

The significantly positive outsourcing association between inventory/transactional and customer service/transactional functions indicates that firms tend to integrate the services of third-party logistics firms across a well-defined sequence of activities that share information from the reception of customer orders and from the execution of shipping orders between the firm's warehouses. The presence of this link strengthens our hypothesis that firms jointly outsource functions across areas in which data exchanges are frequent (Hypothesis 2). This joint outsourcing practice could result in the development of synergies based on a more effective coordination of transactions and the avoidance of extensive investments of capital.

Table IV and Figure 4 also illustrate a significantly positive association between outsourced logistics information systems and outsourced logistics functions in the inventory/transactional, and customer service/transactional areas. These relationships are consistent with Hypothesis 4[11]. It may be the case that firms are jointly outsourcing these logistics areas to overcome previously existing logistics information asset and knowledge deficiencies and reduce overall cost performance gaps with other competitors through the consolidation of physical elements, i.e. capital assets and staff, and the coordination of compatible virtual elements, i.e. network configurations and applications (Venkatraman, 1997; Greis and Kasarda, 1997).

The significantly positive outsourcing association between inventory/transactional and inventory/physical functions and between customer service/transactional and customer service/physical functions supports our hypothesis that firms will jointly outsource functions within the inventory and customer service areas to possibly take advantage of their complementary routine operations, capital assets and technological tools (Hypothesis 5). Authors have indicated that these commonalities might generate synergies that would ultimately be reflected in the achievement of economies of scale, the improvement in delivery performance, and the expansion of the logistics system's geographic coverage. Specifically, as Maltz and Ellram (1997) explain, companies outsource logistics activity clusters (such as those outlined above) to improve their customer service capabilities and reduce costs in the interface of the logistics activities.

Finally, Table IV and Figure 4 illustrate a significantly negative association between outsourced logistics functions in the transportation/transactional and in the transportation/physical areas. Indeed, only 12 per cent of the respondents indicated that their firms are outsourcing transportation/transactional functions along with transportation/physical functions. These findings contradict Hypothesis 5, in the sense that firms are not outsourcing complementary physical and transactional activities in the transportation area. The significantly negative correlation between the transportation/transactional and transportation/physical coefficients indicates that firms tend to rely on third-party providers of transportation services to perform either transaction-oriented activities or physical-oriented activities, but not both. Firms outsourcing fleet management and other transportation/physical activities are less likely to contract third-party transportation/transactional activities such as freight payments and auditing.

The insignificant correlation coefficients between transportation/ transactional and the other logistics areas indicate that firms acquiring the transportation/transactional services of third-party providers do not actively bundle these services with other functions. Transportation/transactional functions have two major components: freight payments and auditing and carrier selection and rate negotiation. These results

demonstrate that among our respondents, outsourcing these activities has been approached independently, unlinked to outsourcing other logistics functions[12].

Conclusions

This paper presents a synopsis of previous academic research on logistics functional processes. Over the last 25 years, authors have identified transportation, inventory, and customer service as distinct functional areas within generic logistics systems. In turn, within each one of those functional areas, authors have identified transactional and physical activities, which are linked by information and material flows, respectively. Authors have identified the planning, operation, and monitoring of these materials and information flows as supply-chain information and material management, respectively. Authors have also identified logistics information systems as enablers and facilitators of the management of these information flows.

This paper also expands previous research on logistics functional processes and logistics outsourcing. An empirical approach allows the authors to conclude that, in deciding to contract the services of third-party logistics providers, firms bundle functional areas and activities in distinct patterns which, as suggested by previous authors, might enable the achievement of efficiency gains reflected in the achievement of economies of scale, scope, and conjunction. The results indicate that firms outsource bundled transactional and physical functions within inventory and customer-service areas. Firms might adopt this outsourcing practice in order to achieve economies of scale resulting from the coordination of complementary routine operations such as stocking of finished goods and the planning of inventory and shipping requirements. Firms might also bundle these outsourced logistics functions in order to obtain a higher efficiency in the utilization of capital assets such as warehouses.

In addition, the results provide evidence that firms outsource groups of logistics functions which share common transactional elements and information flows and logistics functions which share complementary flows of goods. Finally, the results provide evidence that firms bundle the outsourcing of logistics information systems with the information flows across transactional functions such as inventory management and shipment planning. Firms might choose to adopt these outsourcing practices in order to improve their customer service without having to commit significant amounts of financial resources.

Managerial implications

In terms of its practical implications, the study provides firms with an overall view of important elements involved in the decision-making process of logistics outsourcing. Specifically, the paper identifies well-defined sets of integration linkages (across information and material flows and within each logistics functional area) that could serve as guidelines to firms planning logistics outsourcing actions.

This study also provides third-party logistics firms with a tool to plan their service offerings. The study's results show, for example, that a significant proportion of respondents (25 per cent) indicated that their firms are exclusively outsourcing transportation/transactional services. Therefore, a third-party logistics firm specializing in this particular area may be able to pool sufficient numbers of customers to justify its operations economically.

On the other hand, only a small proportion (3.2 per cent) of the survey respondents indicated that their firms outsource transportation/physical functions exclusively. In addition, a minority of respondents (only 4.1 per cent and 0.53 per cent, respectively) indicated that their firms exclusively outsourced customer service/physical and customer service/transactional functions. This research shows that these are functions which firms are more likely to outsource jointly with other activities in the inventory/transactional and inventory/physical areas. Therefore, a third-party firm specializing in any of these logistical areas should plan to offer services in an integrated way in order to be able to consolidate a customer base that economically justifies its operations.

Future research

This research opens the way for other in-depth studies of the bundling of logistics functions for

outsourcing purposes. Detailed case studies analyzing the internal decision-making processes followed in bundling logistics functions for outsourcing are a natural complement to the results presented above. Further insight in the outsourcing bundling process can also be gained with additional studies which expand the scope of the types of logistics functions outsourced. For example, it would be of interest to determine how the outsourcing of logistics functions such as freight consolidation and freight trans-shipments is synchronized with the outsourcing of other functions in the transportation/physical, inventory/physical, and inventory/transactional areas. Furthermore, it would be of interest to analyze what is the outsourcing relationship of additional customer cervice/transactional activities such as demand forecasting with other logistics functions in customer service/physical and inventory/transactional areas.

Additional studies might also concentrate on analyzing integrated outsourcing processes across several industrial sectors, such as the chemical, electronics, and retail/wholesale trade industries. We believe that these industries could provide a comprehensive view of how intermediate-good, manufactured-good, and service industries are partnering with third-party logistics providers. Another stream of research could concentrate on identifying common logistics outsourcing sequences in order to establish which functions are outsourced initially and which functions are outsourced subsequently. Finally, research could also focus on establishing actual performance improvements - reflected in cost-savings and customer-satisfaction effects - associated with the integrated outsourcing of particular strings of activities.

Clearly, there is a need for a longitudinal assessment of the logistics outsourcing process across a wide spectrum of industries and firms. Such an approach would establish exact bundling strategies and provide an opportunity to define impacts of differing strategies on total logistics costs.

The approach presented in this paper provides an impetus for such a longitudinal assessment. This paper has taken cross-sectional data and drawn associations and implications about the timing of logistics outsourcing and bundling of outsourced services. A longitudinal approach could draw on and build on the cross-sectional assessment by observing actual outsourcing bundling strategies and controlling for the impact of specific synergistic strategies of logistics outsourcing.

Notes

1. There has been extensive work, in general, on logistics outsourcing. This work includes the following: Bagchi and Virum (1996, pp. 93-107), Bardi and Tracey (1991, pp. 15-21), Bowersox et al. (1989), Lieb and Randall (1996, pp. 305-20), Cooper (1993, pp. 12-23), Murphy and Daley (1994, pp. 22-7), Rao and Young (1994, pp. 11-19), Sheffi (1990, pp. 27-35), Sink and Langley (1997, pp. 165-82), Tate (1996, pp. 7-13), and Virum (1993, pp. 355-70).

2. Transportation and Distribution had surveyed its subscribers and identified those with significant experience and decision-making authority on logistics outsourcing. The individuals in this sample might have been working for firms that were involved in logistics outsourcing activities before or at the time the respondents answered the questionnaire. Alternatively, the individuals might have been involved in their firms' logistics outsourcing planning activities with the possible objective of outsourcing one or several logistics functions in the foreseeable future.

3. The information in the database had two important drawbacks. First, there were multiple names from some organizations. Approximately 25 percent of the names had at least one other potential respondent from the same organization. Second, some respondents were excluded since they worked for third-party logistics, consulting or educational organizations. We considered that these organizations could not have provided information necessary to answer our logistics outsourcing research questions.

4. The majority of the 463 respondents to our survey (53.6 per cent) were managers in the areas of logistics, operations, distribution, transportation, traffic, purchasing, or materials. Furthermore, 17.5 per cent of the 463 respondents were directors in the areas of logistics, distribution, transportation, traffic, or purchasing. Only 13.2 per cent of the respondents to our survey occupied supervisor or specialist-level positions in their firms, while 5.0 per cent of the respondents to our survey were vice-presidents of logistics or chief logistics officers.

5. Very few (less than 20) surveys were returned to the researchers with an unknown addressee.

6. A review of survey-based logistics outsourcing research published between 1994 and 1998 in the International Journal of Physical Distribution and Logistics Management, the Journal of Business Logistics, and the International Journal of Purchasing and Materials Management showed response rates ranging between 14 per cent and 40.8 per cent and between 41 and 204 respondents.

7. At the 5 per cent significance level, one would expect about two or three of the comparisons to be different by chance, therefore indicating no systematic bias. We also conducted tests at the 10 per cent, 20 per cent, and 30 per cent significant levels. In each case the number of significant differences were equal to what we would expect by chance.

8. Of the firms in our sample, 15 per cent have between 1,000 and 2,499 employees, while 36.3 per cent have 2,500 or more employees. Corresponding percentages from the population were 9.2 per cent and 5.8 per cent, respectively.

9. To operationalize the model in Figure 3, we created a variable for each of the seven logistics areas: logistics information systems, transportation/transactional, transportation/physical, inventory/transactional, inventory/physical, customer service/transactional, and customer service/physical. Each of the seven variables took a value of one if a survey respondent reported that his/her firm was currently outsourcing at least one of the functions corresponding to the particular logistics areas. On the other hand, each of the seven variables was assigned a value of zero if a respondent reported that his/her firm was not currently outsourcing any of the functions corresponding to the particular logistics area.

10. There may be some debate regarding the classification of some of the logistics functions as part of certain logistics areas. In order to address this issue, we tested for the model's robustness to changes in the assignment of logistics functions to each of the seven functional areas. In one of the tests we assigned the function of packaging to the inventory/physical area and removed it from the customer service/physical area. In another test we removed the function of shipment planning from the inventory/transactional area and assigned it to the transportation/transactional area. Both modifications did not change the bivariate-correlation and the logistic-regression results presented in the paper.

11. As suggested by one of the reviewers, the correlation values between logistics information systems and the inventory/physical and customer service/physical areas may be spurious. For example, the correlation between inventory/physical and logistics information systems could be the result of the direct correlation between inventory/transactional and inventory/physical on one hand, and inventory/transactional and logistics information systems on the other hand.

12. Logistics regression models were run to determine how the likelihood of outsourcing a particular logistical area is affected by characteristics of firms contracting third-party logistics services and by the outsourcing of other logistical areas. The firm characteristics used were annual level of sales, number of employees, and geographic scope of operations. The probabilistic relationships from the logistic regression model support our correlation analysis. Indeed, all the significantly positive and negative outsourcing pair-wise associations identified in the bivariate correlation were also identified in the logistic regression equations. The inclusion of firm characteristics in the analysis did not impact the outsourcing relationship among the logistics areas analyzed.

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Appendix. Best practices in managing logistics outsourcing survey

Section 1

The first part of the survey sought information about logistics functions performed by third-party

logistics providers for each one of the respondents.

Listed below are key logistics functions. For each function, please circle

Yes.....if it is currently performed for your company by a third-party provider.

No longer....if it was once performed for your company by a third-party provider, but currently is not.

May.....if your company intends to have a third-party provider perform it in the future.

N/A.....if none of the above apply.

If you respond yes or no longer, indicate in the far right column how many years a third-party provider has performed or previously performed that function.

Years

performed

1 All supply chain functions.....YesNo longerMayN/A

2 Logistics information systems.....YesNo longerMayN/A

3 Carrier selection/rate negotiation.....YesNo longerMayN/A

4 Shipment planning.....YesNo longerMayN/A

5 Fleet management.....YesNo longerMayN/A

6 Warehousing and operations.....YesNo longerMayN/A

7 Freight payments/auditing.....YesNo longerMayN/A

8 Inventory management.....YesNo longerMayN/A

9 Packaging.....YesNo longerMayN/A

10 Order processing/fulfillment.....YesNo longerMayN/A11 Product returns.....YesNo longerMayN/A

Section 2

The second section of the questionnaire sought information about the respondents and their companies.

Company's name _____

Main line of business _____

Annual company sales volume in dollars?Number of company employees?

1 $50 million or less 1 less than 100

2 More than $50 million, up to $100 million 2 100-249

3 More than $100 million, up to $500 million 3 250-499

4 More than $500 million, up to $1 billion 4 500-999

5 More than $1 billion 5 1,000-2,499

6 5,000 or more

Geographic scope of company operations? (check one)

1 Regional

2 National

3 Worldwide

Your name and phone number

Your title

Your address

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GRAPHIC: ILLUSTRATION; Caption: Table I.; Summary of research hypotheses; Table II.; Distribution of industrial segments compared against the distribution of the population; Table III.; Extent of logistics outsourcing; Table IV.; Pair-wise linkages in logistics outsourcing - correlation method: Pearson correlation; Figure 1.; Logistical system components; Figure 2.; Research hypotheses; Figure 3.; Classification of surveyed logistics functions; Figure 4.; Pair-wise linkages in logistics outsourcing

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Inventory Reduction Report

May 1996

SECTION: Pg. 2

LENGTH: 951 words

Getting started with VMI requires some investigation first. According to consultant James D. Krasner, director of logistics services, Grant Thornton LLP (Chicago), "VMI has become a key element of the inventory deployment process that will lower supply chain costs." However, success, as in any customer/supplier partnership arrangement, is not always assured. To help organizations starting to consider a VMI relationship, Krasner developed a 16-question test (see sidebar) that can "provide the path to helping assure the manufacturer/supplier business relationship works effectively and efficiently."

According to Daphne Perry, general manager, ECR, H.J. Heinz Company of Canada Ltd., "Vendor managed replenishment is the ideal way to start continuous replenishment." That is, if the vendor (or approved third party) has trained personnel, systems, and process controls to manage sales forecasting and order replenishment functions for their continuous replenishment partners. "Correspondingly, accurate and timely data records (on-hand inventory, daily sales, in transit) from distributors/retailers is mandatory," she argues. EDI transmissions must be managed to a preagreed schedule and universal product codes and product attributes must be verified. Based on her experiences, she concludes, "Vendor managed replenishment results are substantial and can be realized in the first year." *

16 Questions That Must Be Answered to Begin A Successful VMI Relationship

1. Who owns the inventory?

* The company that has the lowest financing rate

* The company that has an ROA requirement that best support inventory holding

* The company where the inventory will be least likely to become obsolete

2. When does the transfer of ownership occur?

* If the manufacturer is best suited to own the inventory, then it's as soon as the component is produced
* If the supplier is best suited to own the inventory, it's when the component is used by the manufacturer

3. Where is inventory located?

* The location that will most reduce cycle time, without committing too much safety stock inventory downstream
* The location that has the lowest cost space, as long as it is available
* The location that has the most efficient, effective distribution center operations

4. Who projects demand?

* The company that has the best tools
* The company with the most complete information
* The company with broadest perspective: for finished good, typically the manufacturer; for components, the manufacturer or the supplier; and for materials, the manufacturer or the supplier or the supplier's supplier

5. Who monitors inventory levels?

* Everyone
* All levels of the supply chain

6. How are orders placed?

* The planning systems automatically generate a replenishment request against a blanket purchase order
* This replenishment request is a direct demand input into the supplier's production planning and distribution center systems

7. Who manages the movement of inventory?

* The company with best tools and capabilities, including deployment planning, transportation, and distribution center control
* The operation where the inventory is physically located keeps track of inventory status

8. When are payments made?

* Immediately upon the transfer of ownership

9. How are the payments made?

* Via electronic funds transfer, no invoicing

10. Who finances the inventory?

* Ultimately, one of the company's shareholders
* The company that takes on the value-adding role of holding inventory (based on shareholder acceptance)
* Not necessarily the company where the inventory is located

11. Who owns the space to store the inventory?

* The company whose ROA on warehouse assets is most acceptable to its shareholders
* Not necessarily the manufacturer or the supplier, it could be a third party provider

12. Who pays for the transportation to move the inventory?

* Ultimately, it is the consumer
* The manufacturer absorbs the cost into the product price and passes it on
* The supplier should only receive profit for managing and coordinating the transportation activity

13. Who provides labor for picking the replenishment to the production floor?

* The final selection of components for the manufacturer's assembly process may be performed by the manufacturer, the supplier, or a third party provider, based on who is most effective and efficient and least costly

* The activity can be performed by any of these companies either at the manufacturer's location or elsewhere

14. Who provides for labor planning?

* The company who has the best trained planners and the best planning tools
* Not necessarily the company where the activity is taking place

15. Who provides planning and order administration labor?

* Inter-enterprise and integrated processes should be designed to eliminate as much administrative activities as possible

16. Who develops and supplies information systems support?

* The systems should be co-designed by the manufacturer, key suppliers and third party providers to support the integrated processes
* The company most skilled in carrying out these systems should be responsible for managing its development
* The investment can either be shared or built into component pricing

(Source: James D. Krasner)

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